



**Universidade de Évora**  
*Honesto Estudo com Longa Experiência Misturado*

**GEOMÁTICA**  
**DESENHO TÉCNICO ASSISTIDO POR COMPUTADOR**

Caderno de exercícios: AutoCAD 2020

Ana Cristina Gonçalves

Évora

2020

Textos didáticos

## Índice

<b>I – Introdução ao AutoCAD</b> .....	1
1. Sequência de passos na abertura do AutoCAD .....	1
2. Ajudas de desenho do AutoCAD .....	4
3. Comandos de desenho .....	6
4. Coordenadas relativas .....	7
5. Definição de camadas, tipo da linha e espessura de linha .....	7
6. Definição do estilo do ponto .....	11
8. Ensino presencial .....	12
9. Trabalho não presencial .....	14
<b>II – Projeções e cotação</b> .....	17
1. Definição e formatação da cotação .....	17
2. Ensino presencial .....	20
3. Exercícios de projeções ortogonais .....	22
<b>III – Perspectivas</b> .....	31
1. Seleção de grelha isométrica .....	31
2. Ensino presencial .....	32
3. Exercícios de perspectivas .....	34
<b>IV – Desenho a três dimensões, cortes e secções</b> .....	43
1. Aspectos complementares do desenho a 2D .....	43
2. Transformação de linhas e arcos em poli-linhas .....	44
3. Desenho a 3D .....	45
4. Colocação das ferramentas slice e section na barra Modelling .....	46
5. Ensino presencial .....	48
6. Exercícios de construção a 3D, cortes e secções .....	51

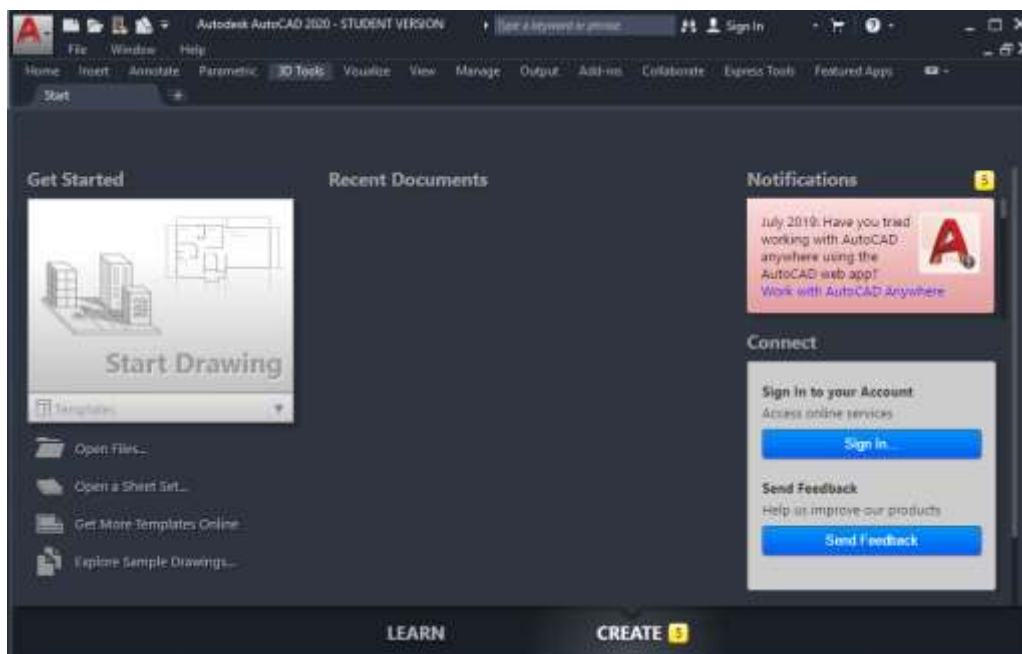
## I – Introdução ao AutoCAD

### Capacidades a adquirir nesta aula:

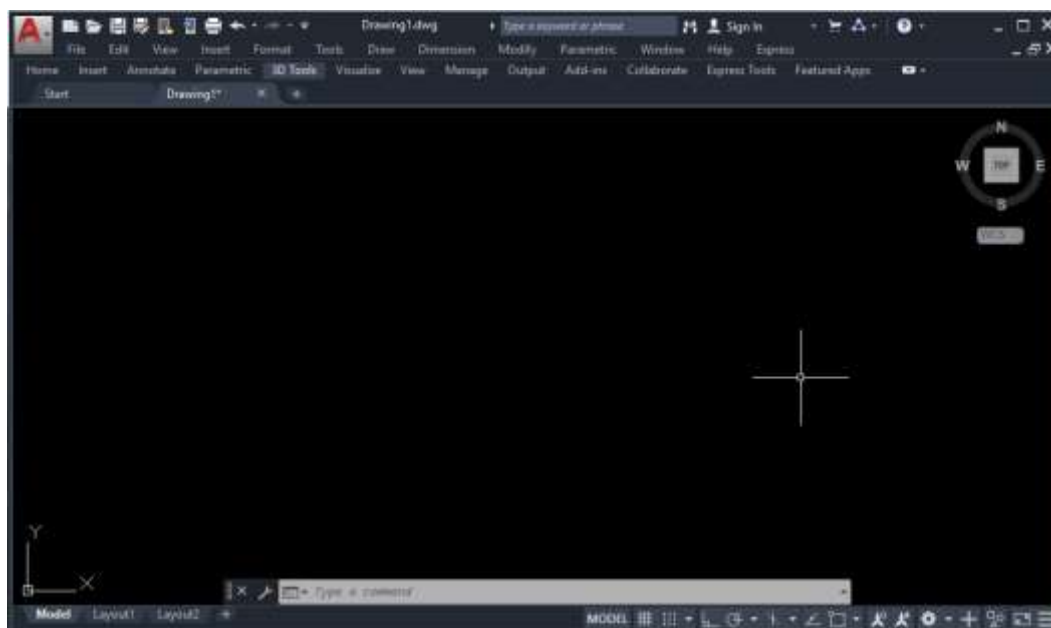
- a) Compreender o sistema de coordenadas absolutas e relativas em AutoCAD;
- b) Desenhar figuras geométricas simples, selecionar o tipo de letra;
- c) Saber editar as figuras, utilizando COPY, ERASE e MOVE;
- d) Saber utilizar as ferramentas de apoio SNAP, 2D OBJECT SNAP; GRID, ORTHO, ZOOM;
- e) Saber gravar e recuperar os desenhos;
- f) Saber utilizar adequadamente os tipos e espessuras de linhas;
- g) Desenhar figuras geométricas mais complexas, incluindo elipses, polígonos e arcos;
- h) Utilizar ferramentas de produtividade tais como ROTATE, OFFSET e MIRROR;
- i) Saber editar as peças utilizando EXTEND e TRIM.

### 1. Sequência de passos na abertura do AutoCAD

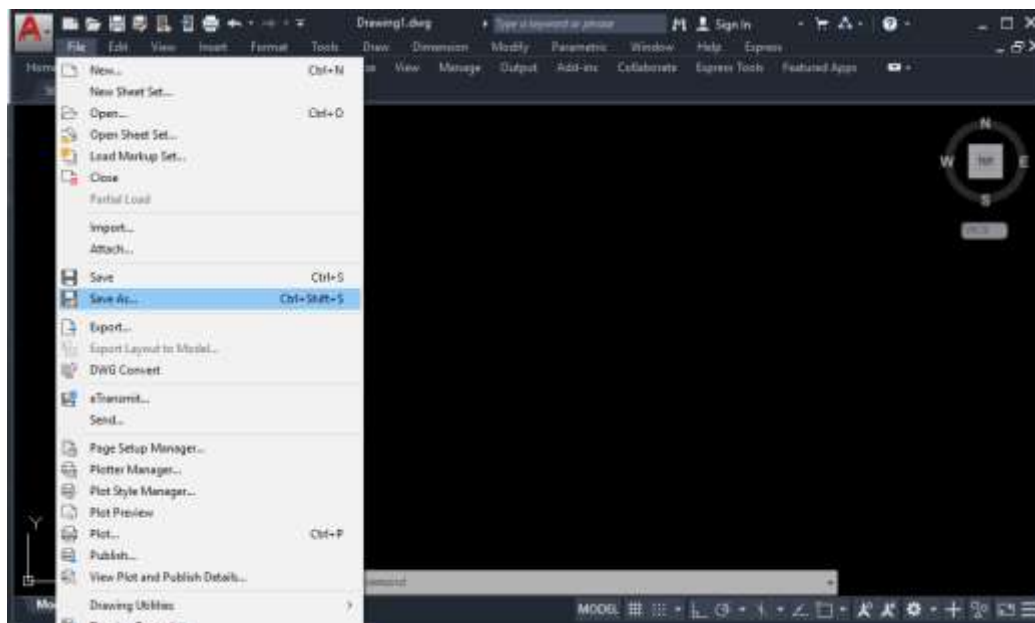
Abrindo o programa Autocad 2020 surge o menu da figura abaixo. Para começar a trabalhar deve-se clicar em “Start Drawing”.



Surge uma folha de desenho com o nome “Drawing1”, correspondente à folha de desenho. Podem abrir-se novas folhas de desenho clicando em “+” na barra que contém as já criadas.



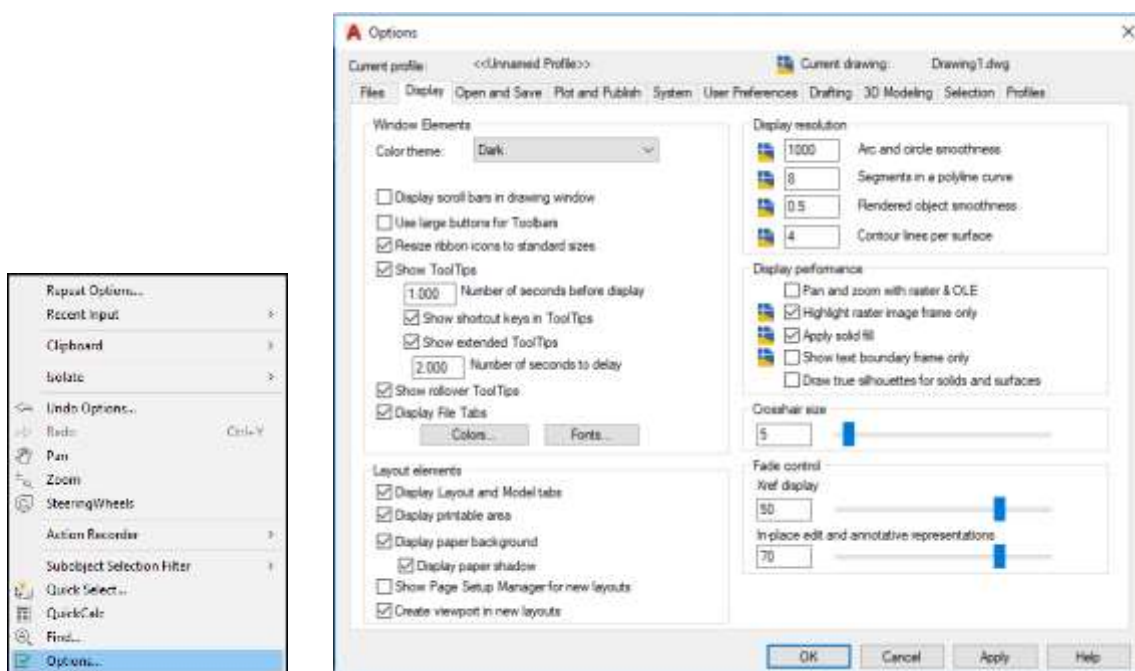
As folhas assim criadas deverão ser guardadas em **File -> Save as ->** e seleccionar a pasta onde vão ser guardados os ficheiros utilizando o explorador do Windows. A extensão dos ficheiros deve ser **dwg**.



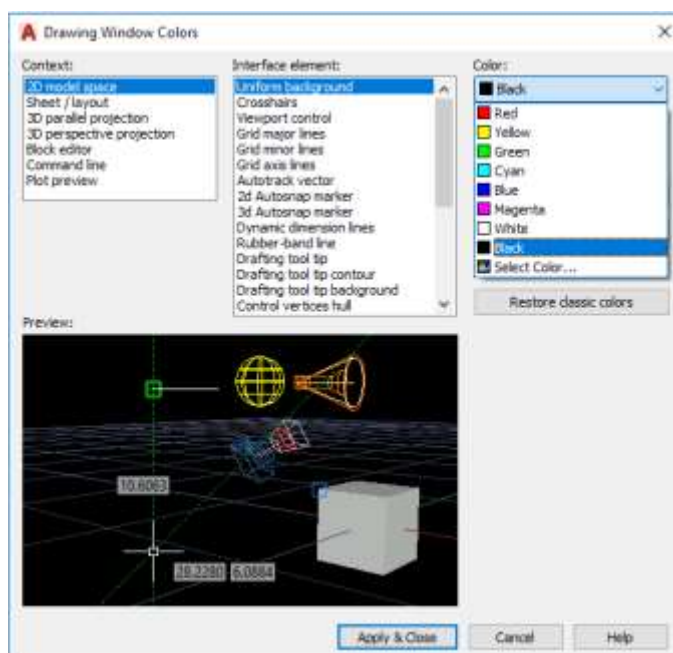
Encontra-se visível a ferramenta de comando, que deve estar preferencialmente colocada na parte inferior, em toda a sua extensão, arrastando a barra pelo canto direito.




As cores de fundo e outras características de aparência podem ser alteradas clicando no botão direito do rato e na janela abaixo indicada, selecionar **Options -> Display**.

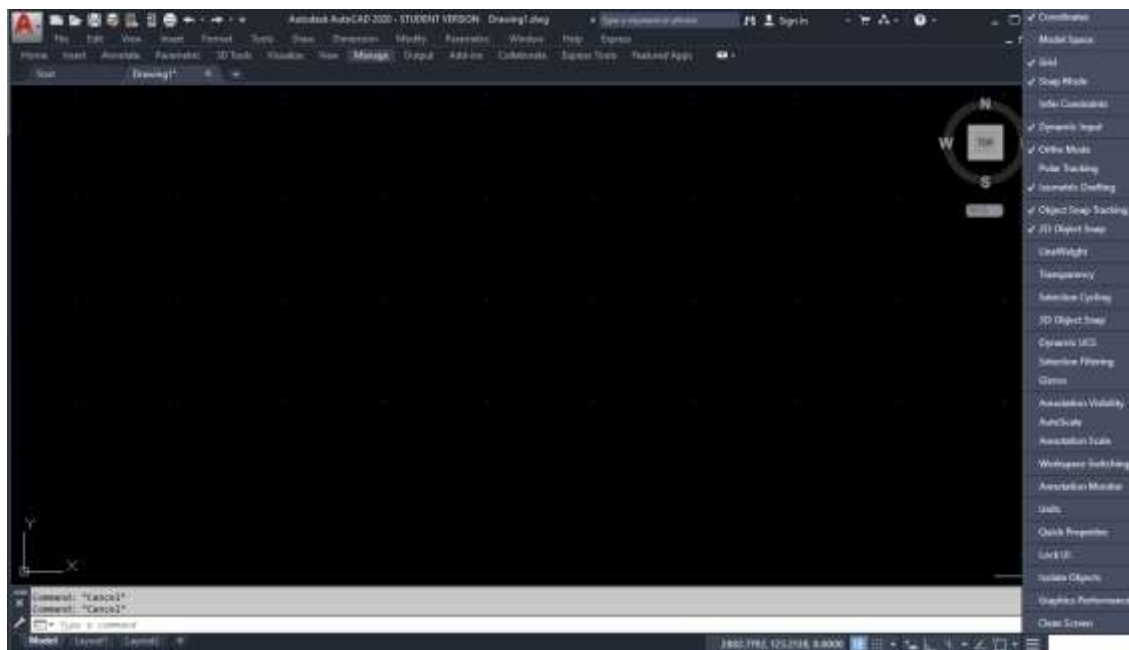


Pode, por exemplo, alterar-se a cor de fundo em **Colors -> Drawing Window Colors -> Color**, finalizando com **Apply and Close**.









## 2. Ajudas de desenho do AutoCAD

No canto inferior direito existe um conjunto de ferramentas que deve estar visível. Podem colocar-se visíveis colocando o rato em  e com a tecla esquerda do rato abrir o menu e seleccionar as ferramentas que se deseja.

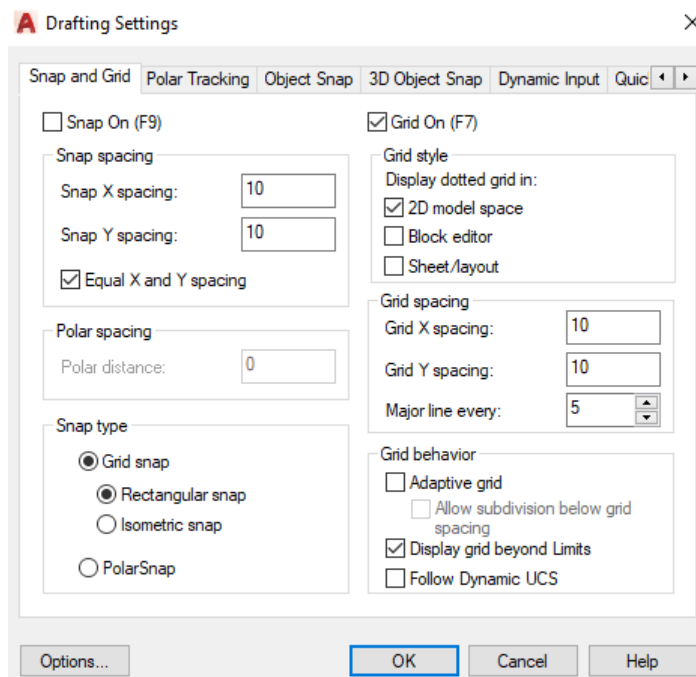


Deverão estar visíveis as seguintes ferramentas:

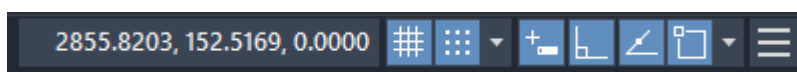
Coordinates		Coordenadas
Grid		Grelha
Snap mode		Posiciona cursor nos pontos da grelha
Dynamic input		Dimensões dinâmicas
Ortho mode		Ortogonal
Object snap tracking		Alinhamento em função de pontos de referência
2D object snap		Posicionar cursor em pontos de referência
Line weight		Espessura de linha

Em cima de um ícone, clique no botão do lado direito do rato e surge a janela que permite ativar o snap, o grid, alterar o espaçamento do grid e do snap.

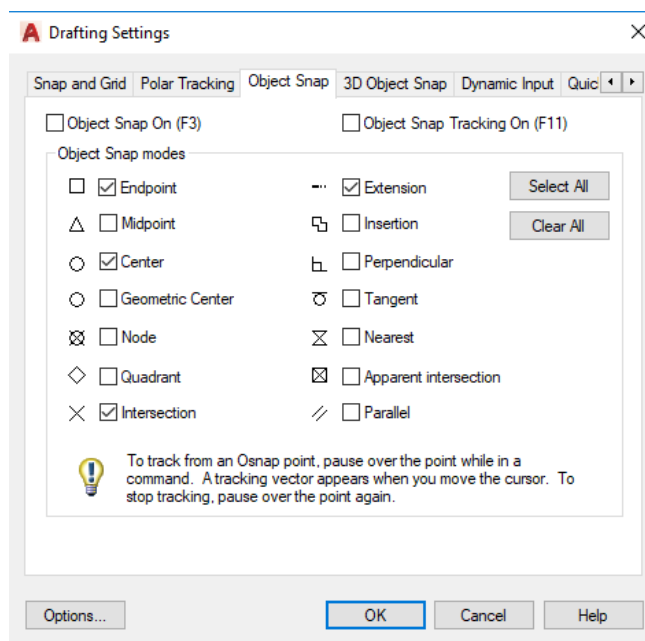
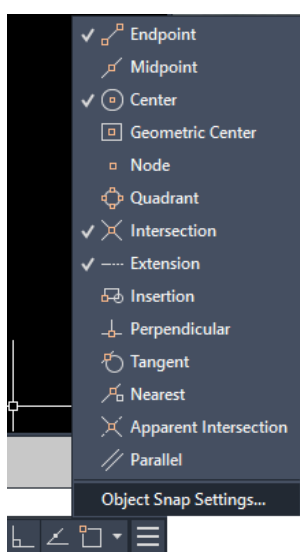
A instrução **line weight** deve estar sempre ativa.



A ativação dos comandos anteriores, pode ser efetuada clicando com o rato em cima dos ícones, tomando estes a cor de fundo azul.

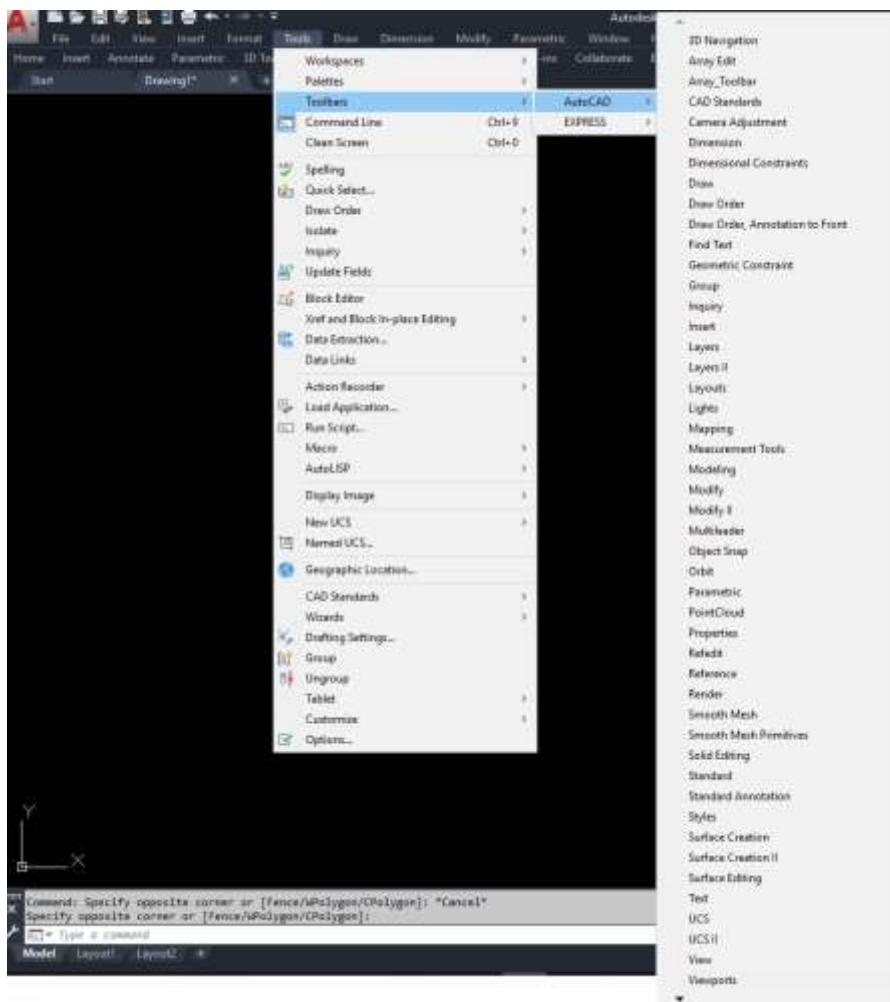


Com o curso em cima do ícone 2D object snap, clicando na tecla esquerda do rato, selecionando Object snap settings, que abre uma nova janela permitindo ativar o tipo de pontos que pretende agarrar.



### 3. Comandos de desenho

É possível colocar as barras de ferramentas no ambiente de trabalho com **Tools -> Toolbars -> AutoCAD**, surgindo uma lista. Selecionando uma barra de ferramentas surge automaticamente no ambiente de trabalho podendo posteriormente ser localizada no local mais conveniente pelo utilizador.



Procure familiarizar-se com os seguintes comandos:

#### TOOLBAR Draw

























#### TOOLBAR MODIFY



#### TOOLBAR Zoom





TOOLBAR <b>DRAW</b>		TOOLBAR <b>MODIFY</b>	
	Line		Erase
	Construction line		Copy
	Polyline		Mirror
	Polygon		Offset
	Rectangle		Array
	Arc		Move
	Circle		Rotate
	Ellipse		Trim
	Ellipse arc		Scale
	Point		Fillet
	Text		Explode

#### 4. Coordenadas relativas

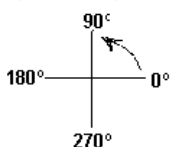
@ Permite introduzir coordenadas relativas.

```
Command:
Command: _line Specify first point:
Specify next point or [Undo]: @5,30,0|
```

##### 5.1 (@ X, Y, Z)

```
Command:
Command: _line Specify first point:
Specify next point or [Undo]: @5<45
```

##### 5.2 (@ d < $\theta$ ) d=distância e $\theta$ o ângulo



#### 5. Definição de camadas, tipo da linha e espessura de linha

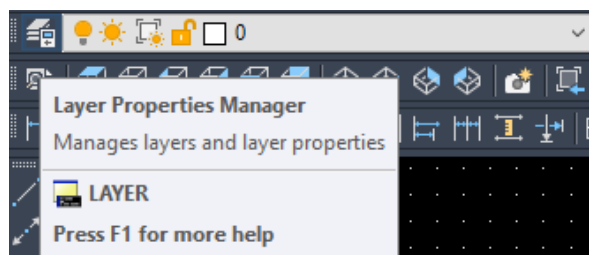
Toolbar **Layers**



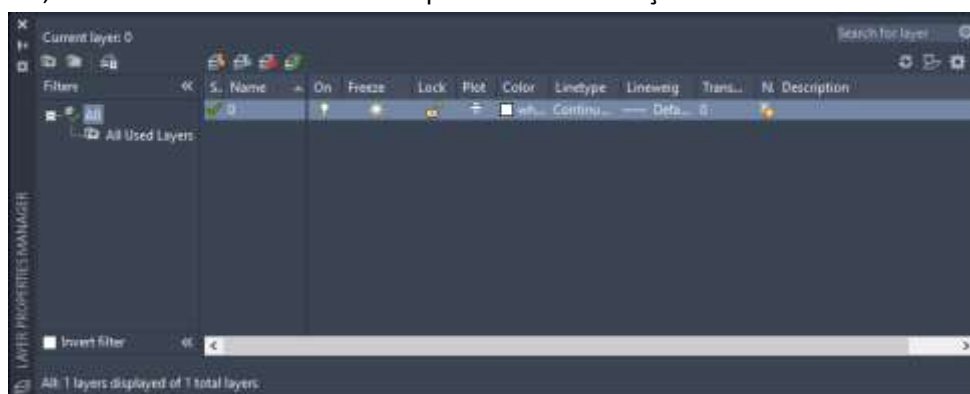
A barra de ferramentas Layers possibilita a construção de desenhos em níveis diferentes, podendo estar ou não visíveis.

Os desenhos são feitos numa ou em várias camadas (“layers”) que se devem formatar quando se criam.

Para criar uma nova camada selecione a instrução **Layers Properties Manager** na barra de ferramentas “Layers”. Surge uma janela com todas as camadas predefinidas pelo sistema.



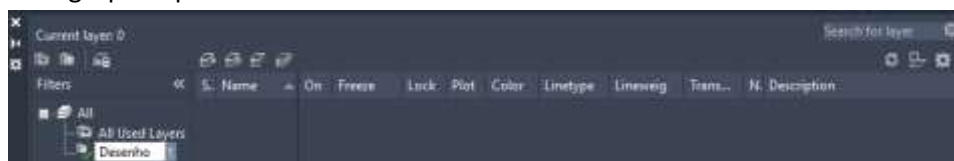
As camadas que se encontram predefinidas podem ser mantidas ou apagadas. Para as apagar deve seleccioná-las, clicar na tecla direita do rato e pressionar a instrução delete.



Para criar um novo grupo de camadas selecione a instrução **New Group Filter** que se encontra:



Surge um novo grupo a que deve dar um nome

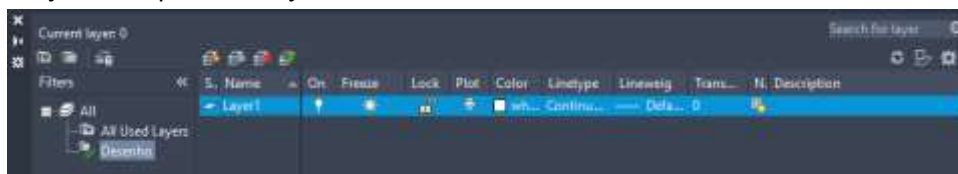


Selecione o grupo que acabou de criar e clique em **New Layer** para adicionar uma nova camada.

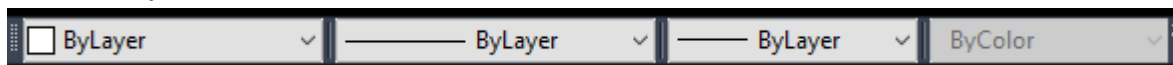


Surge do lado direito a nova camada com as definições por defeito, a que deve dar um nome e formatar a cor, o tipo e a espessura da linha.

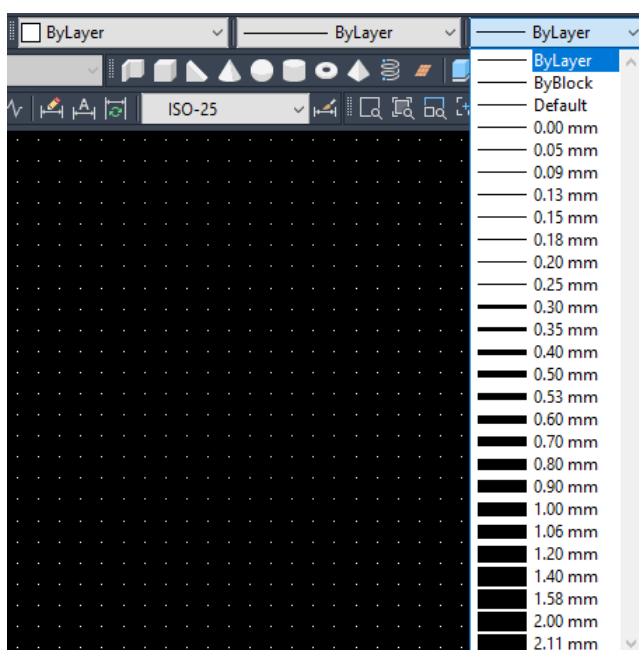
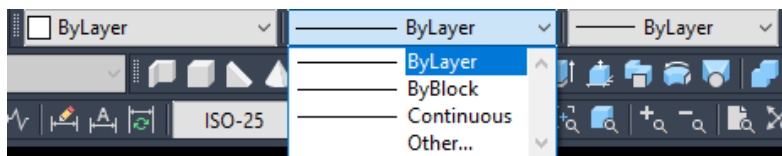
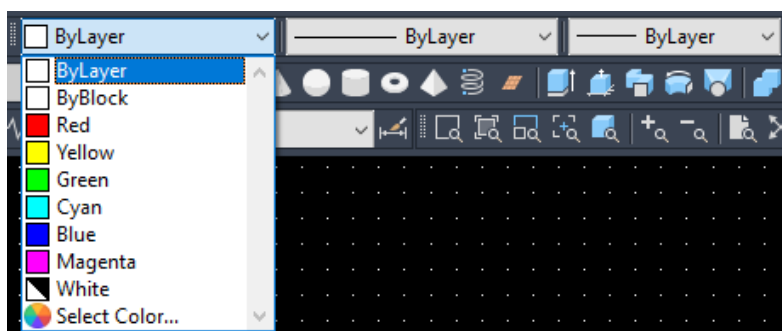
Para as alterar basta clicar duas vezes em cima da cor, do tipo ou da espessura da linha predefinida e selecionar na janela a que se deseja utilizar.



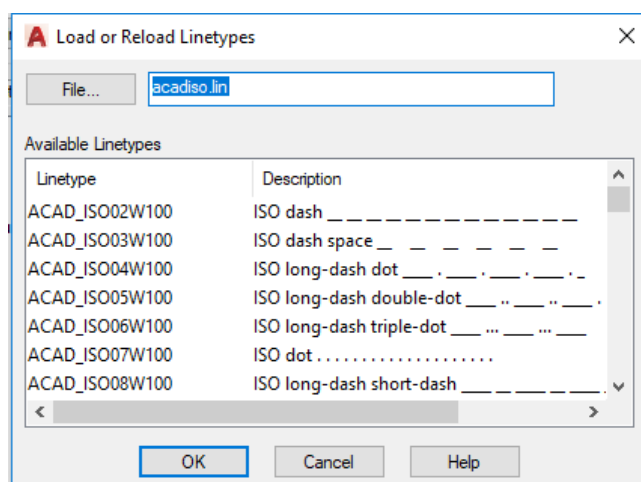
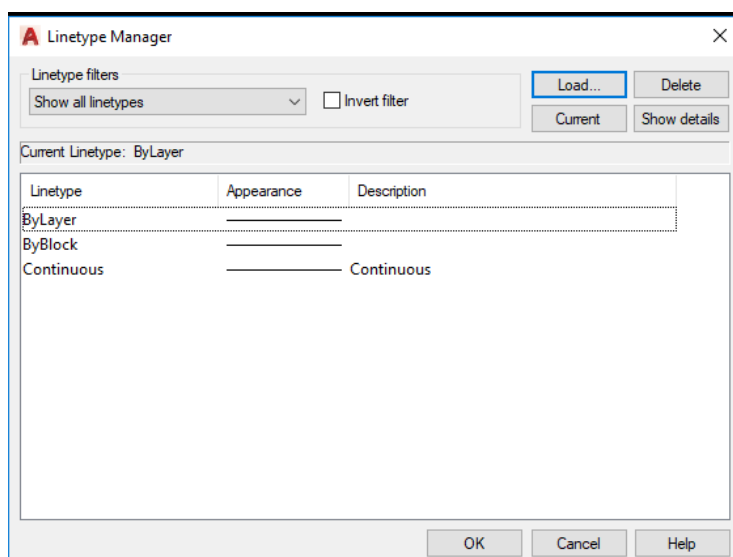
### Toolbar Properties



A cor, espessura e tipo de linha devem preferencialmente ser formatados na layer, aparecendo na barra Properties como “ByLayer”. No entanto, podem alterar-se como se mostra nas figuras seguintes.



Podem acrescentar-se tipos de linhas no **Type line control**, quer quando se formata a layer quer na barra de ferramentas **Properties**. Para tal deve seleccionar-se a opção **other** surgindo uma janela. Seleccionando a instrução **load** surge uma nova janela com os tipos de linha disponíveis no AutoCAD. A inclusão de um novo tipo de linha faz-se seleccionando e clicando OK.



### Ícones importantes

*Novo*



*Abrir*

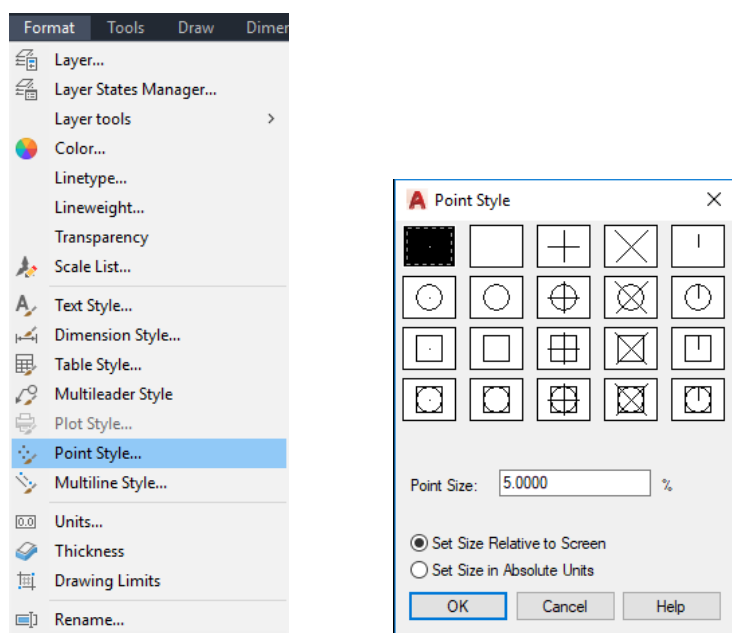


*Gravar*



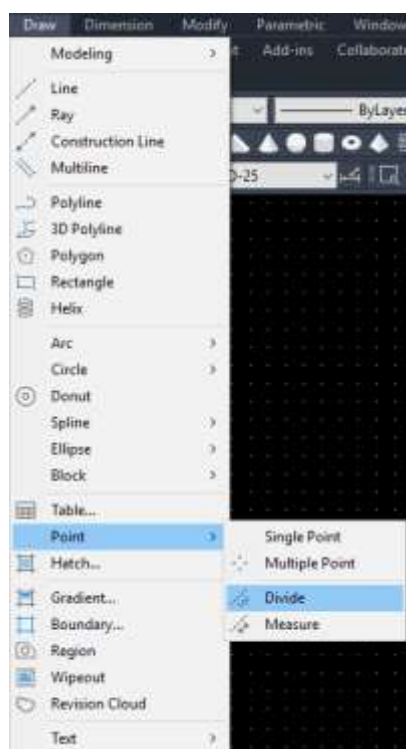
## 6. Definição do estilo do ponto

### Menu **FORMAT / POINT STYLE**



## 7. Divisão de um objeto num qualquer número de peças

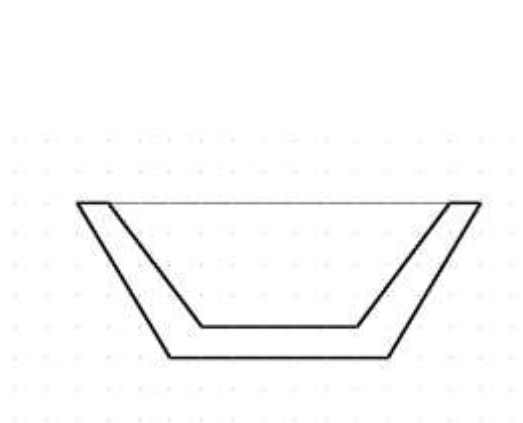
Pode dividir-se um objeto num qualquer número de peças iguais ou dividir em bocados com uma medida predefinida com as ferramentas do Menu **DRAW -> POINT -> Divide**



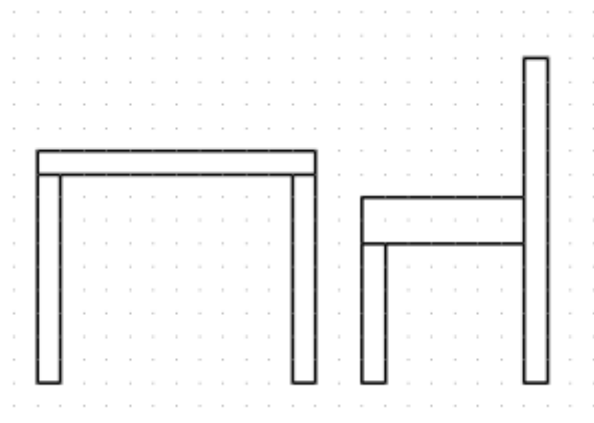
## 8. Ensino presencial

8.1. Desenhe as seguintes figuras (o espaçamento da grelha é 10 unidades)

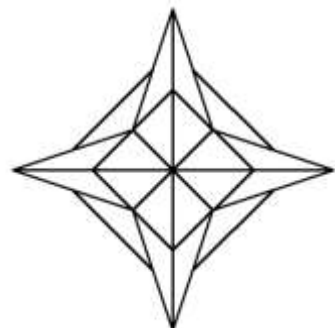
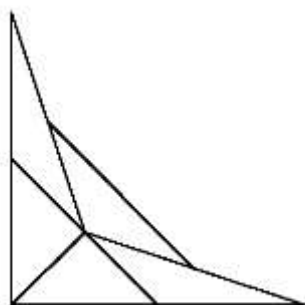
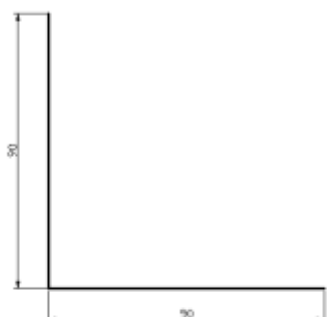
8.1.1



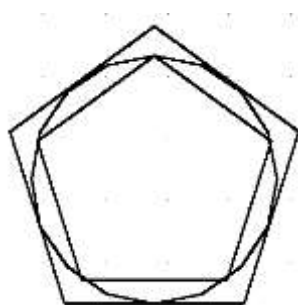
8.1.2



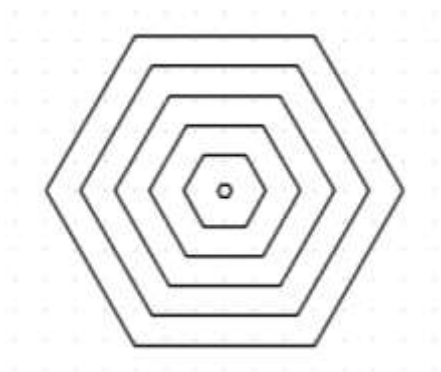
8.1.3 Transforme as duas linhas com 90 mm da figura da esquerda na figura do meio utilizando apenas OSNAP ao ponto do fim (ENDPOINT) e ao ponto do meio (MIDPOINT). Pode obter a estrela da direita utilizando o comando espelho (MIRROR).



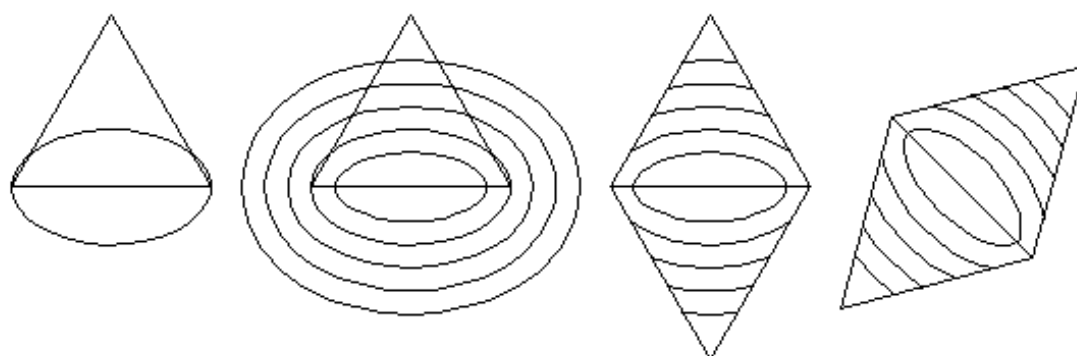
8.1.4 Desenhe um círculo com raio de 50 mm. Desenhe um polígono inscrito e outro que circunscreva o círculo (utilize SNAP ao centro para colocar os polígonos no centro do círculo).



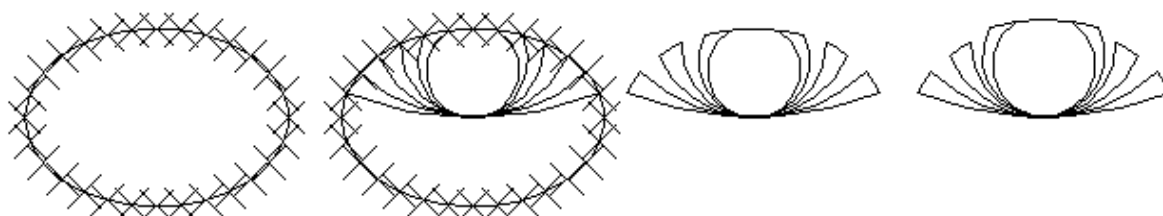
**8.1.5** Desenhe um hexágono com raio de 60 mm. Desenhe 6 hexágonos no seu interior, utilizando um OFFSET de 10 mm.



**8.1.6** Desenhe o triângulo com raio de 50 mm. Inscreva a elipse na base, utilizando SNAP (ao fim) (altura da elipse 25mm). Obtenha mais quatro elipses utilizando o OFFSET de 10 mm. Utilizando corte (TRIM) limpe as elipses fora do triângulo. Utilizando o espelho (MIRROR) obtenha a parte de baixo. Finalmente rode o objeto -45°.

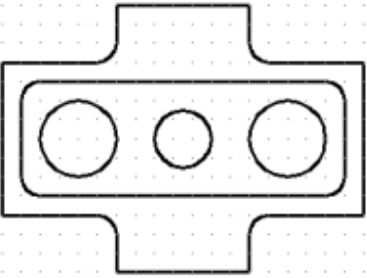

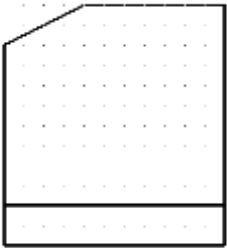
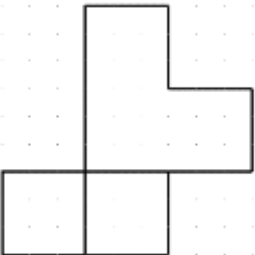
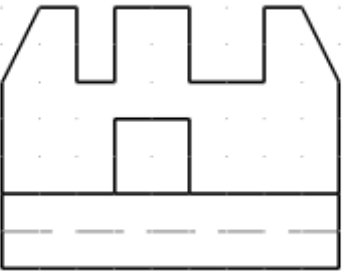
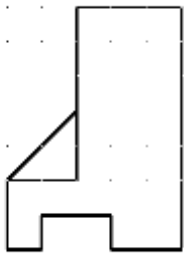
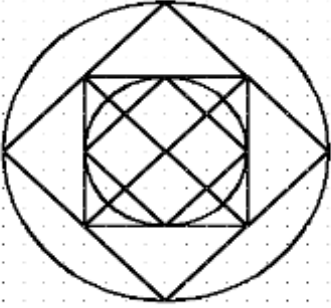
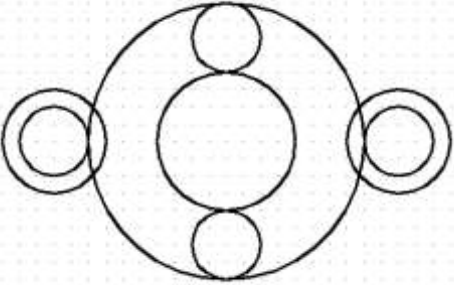


**8.1.7** Desenhe uma elipse com 75 mm de comprimento e 25 mm de raio. Divida-o em 28 peças (POINT>DIVIDE). Aumente o tamanho dos pontos (POINT STYLE) para serem visíveis. Desenhe 6 arcos ligando pontos opostos da elipse, passando pelo seu centro (SNAP ao ponto e OSNAP ao centro da elipse). Limpe a figura. Finalmente amplie (SCALE) a parte do meio em 10%.

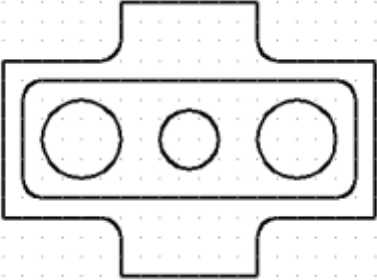
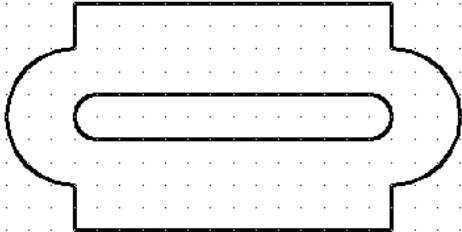
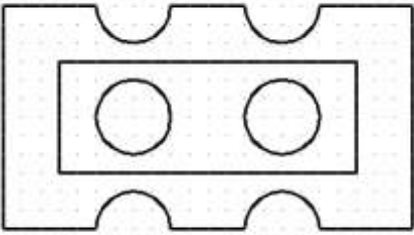

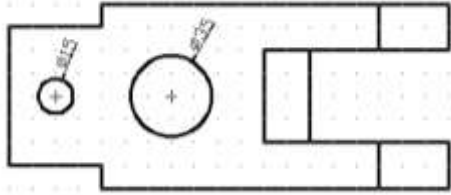
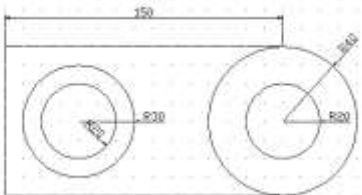
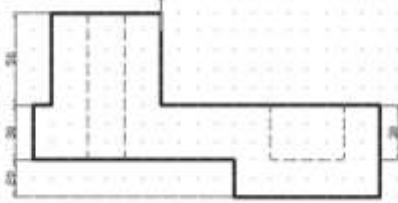
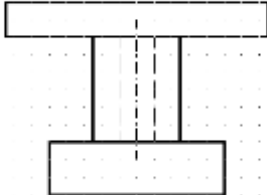
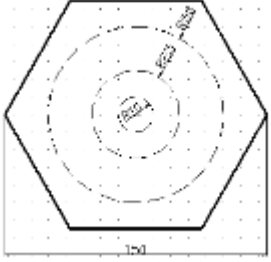
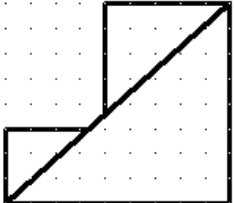


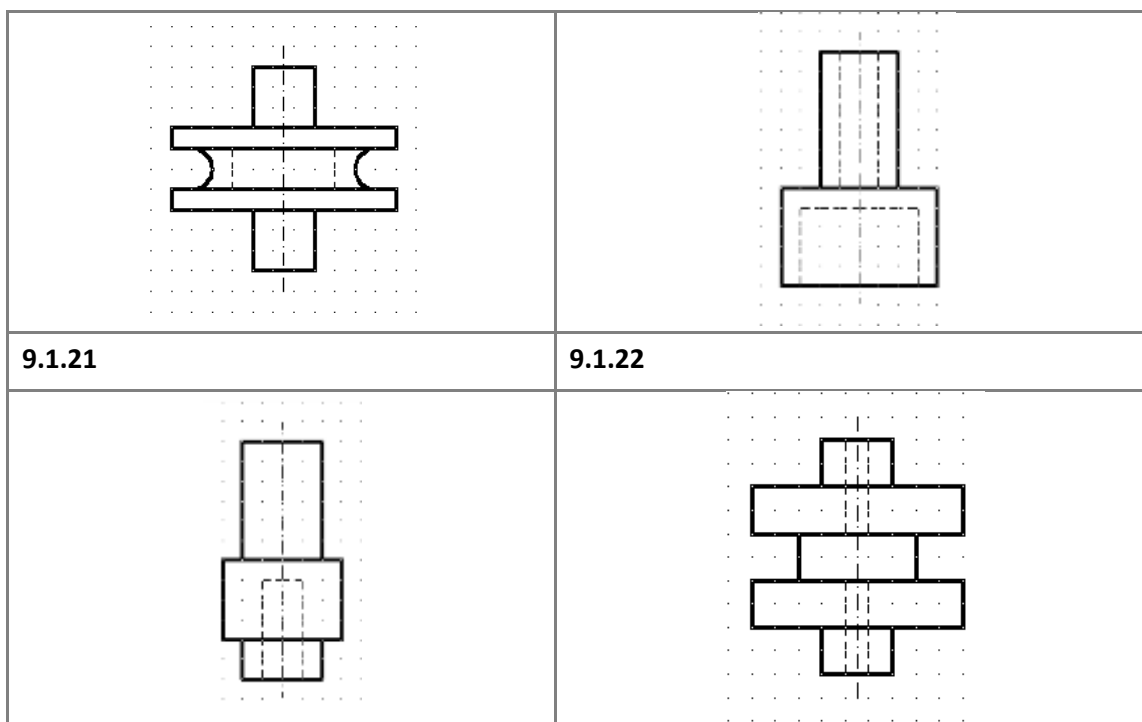
## 9. Trabalho não presencial

9.1 Desenhe as seguintes figuras (o espaçamento da grelha é 10 unidades).

<p><b>9.1.1</b></p> 	<p><b>9.1.2</b></p> 
<p><b>9.1.3</b></p> 	<p><b>9.1.4</b></p> 
<p><b>9.1.5</b></p> 	<p><b>9.1.6</b></p> 
<p><b>9.1.7</b></p> 	<p><b>9.1.8</b></p> 

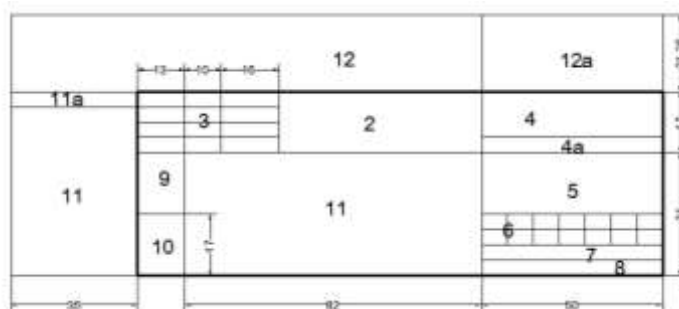
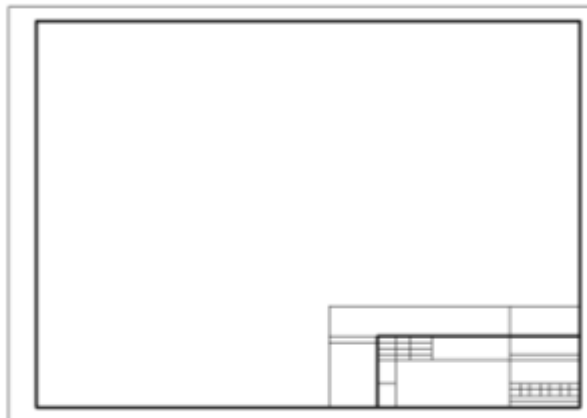


<b>9.1.9</b> 	<b>9.1.10</b> 
<b>9.1.11</b> 	<b>9.1.12</b> 
<b>9.1.9</b> 	<b>9.1.14</b> 
<b>9.1.15</b> 	<b>9.1.16</b> 
<b>9.1.17</b> 	<b>9.1.18</b> 
<b>9.1.19</b>	<b>9.1.20</b>



## 9.2

**Normalização:** Desenhe a esquadria e a legenda numa folha A3 de acordo com norma NP-204 (ligue o comando ORTHO). Guarde esta folha para utilizar sempre que precisar.



## II – Projeções e cotação








### Capacidades a adquirir nesta aula:


- Utilizar a cotação para indicar a forma e a localização dos elementos de uma peça;
- Selecionar criteriosamente as cotas, as vistas onde devem ser inscritas e a sua orientação;
- Aplicar as técnicas de cotação de modo a garantir a legibilidade, simplicidade e clareza do desenho em AutoCAD;
- Apresentar os desenhos com as cotas numa camada diferente;
- Solicitar ao computador propriedades dos objetos desenhados.

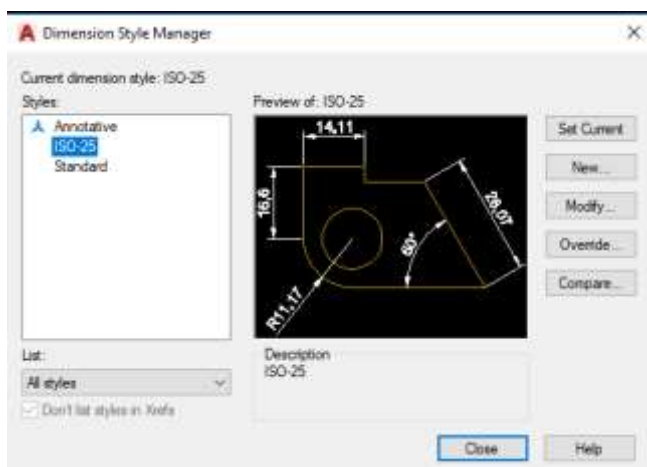
### 1. Definição e formatação da cotação

#### 1.1 Toolbar Dimension



-  Dimensão linear
-  Dimensão alinhada
-  Dimensão radial
-  Dimensão diametral
-  Dimensão angular
-  Dimensão paralela
-  Dimensão contínua

**Dimension styles**  - Permite definir as características dos elementos de cotação.

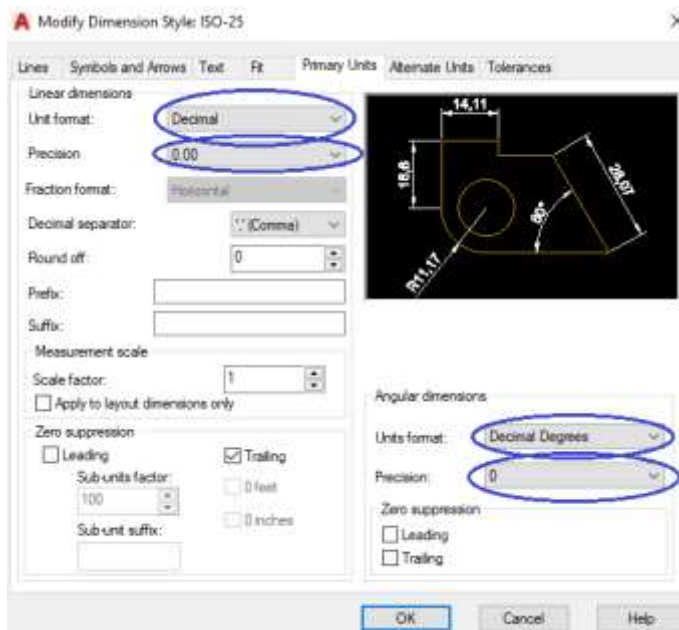


Para alterar a formatação dos elementos de cotação deve clicar em **Modify**.

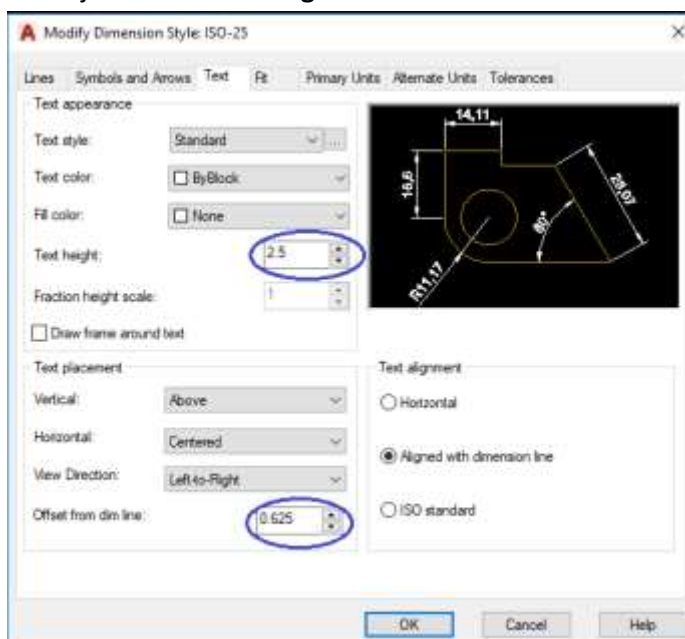
Surge uma nova janela com os menus: **Lines**, **Symbols and Arrows**, **Text** e **Primary units**, permitindo adequar a formatação dos elementos de cotação à especificidade de cada desenho ou projeto. Para tal siga os seguintes passos nas janelas:

- 1) **Primary units** altere **Linear dimensions** e **Angular dimensions**, **Unit format** e **Precision**, para a formatação adequada;
- 2) **Text** pode alterar-se **Text height**, altere a altura do texto de modo que seja claramente legível;
- 3) **Symbols and Arrows** altere **Arrow size**, de modo que seja claramente legível;
- 4) **Text** altere **Offset from dim line**, de modo a que seja adequado à dimensão da altura do texto;
- 5) **Lines** altere **Baseline spacing**, **extent beyond dim lines** e **offset from origin**, de modo a que seja adequado à dimensão da altura do texto.

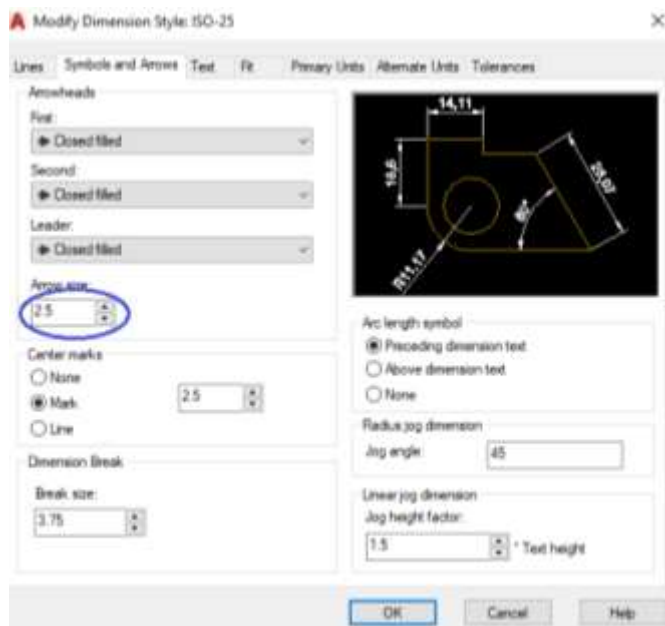
**Primary units** ajustam-se **Linear dimensions** e **Angular dimensions**, **Unit format** e **Precision**.



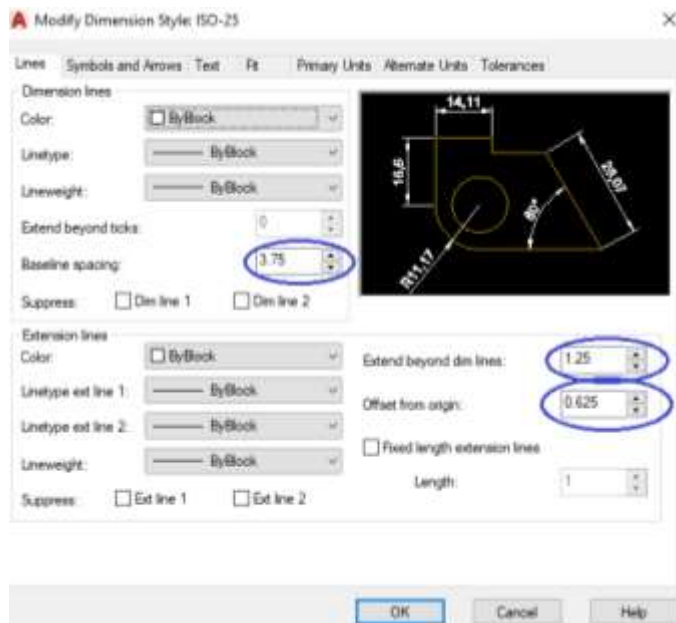
**Text** ajustam-se **Text height** e **Offset from dim line**.



## Symbols and Arrows ajustam-se Arrow size.



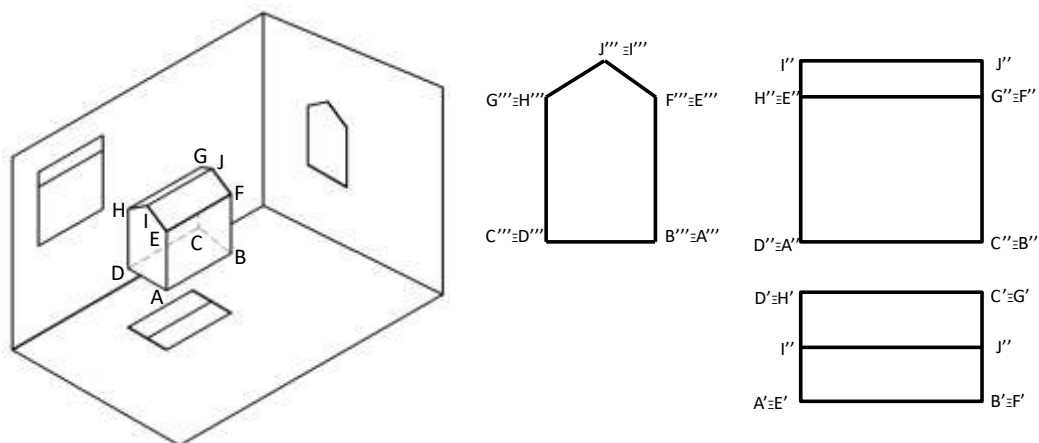
## Lines ajustam-se Baseline spacing, extent beyond dim lines e offset from origin



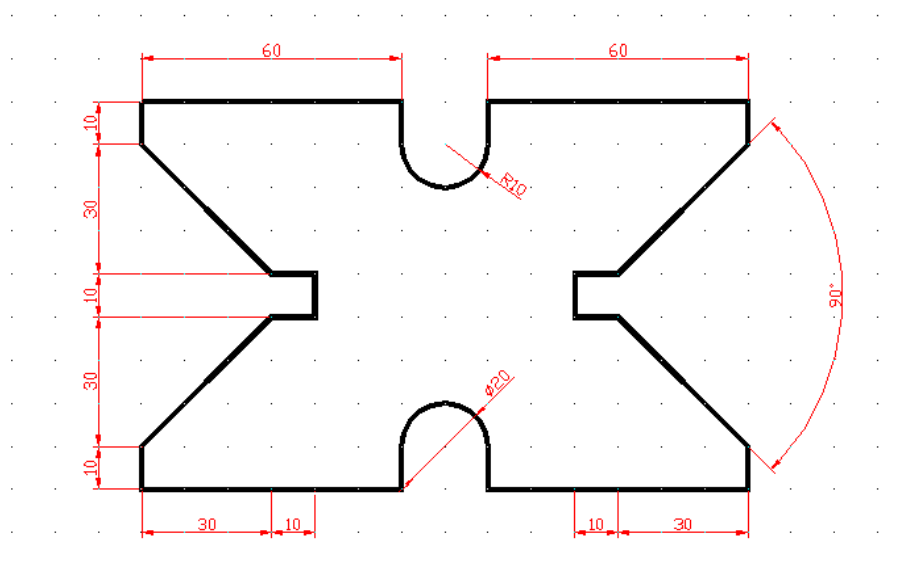
## 2. Ensino presencial

2.1 A partir da figura da esquerda desenha a sua projeção de acordo com o método Europeu, de acordo com as indicações:

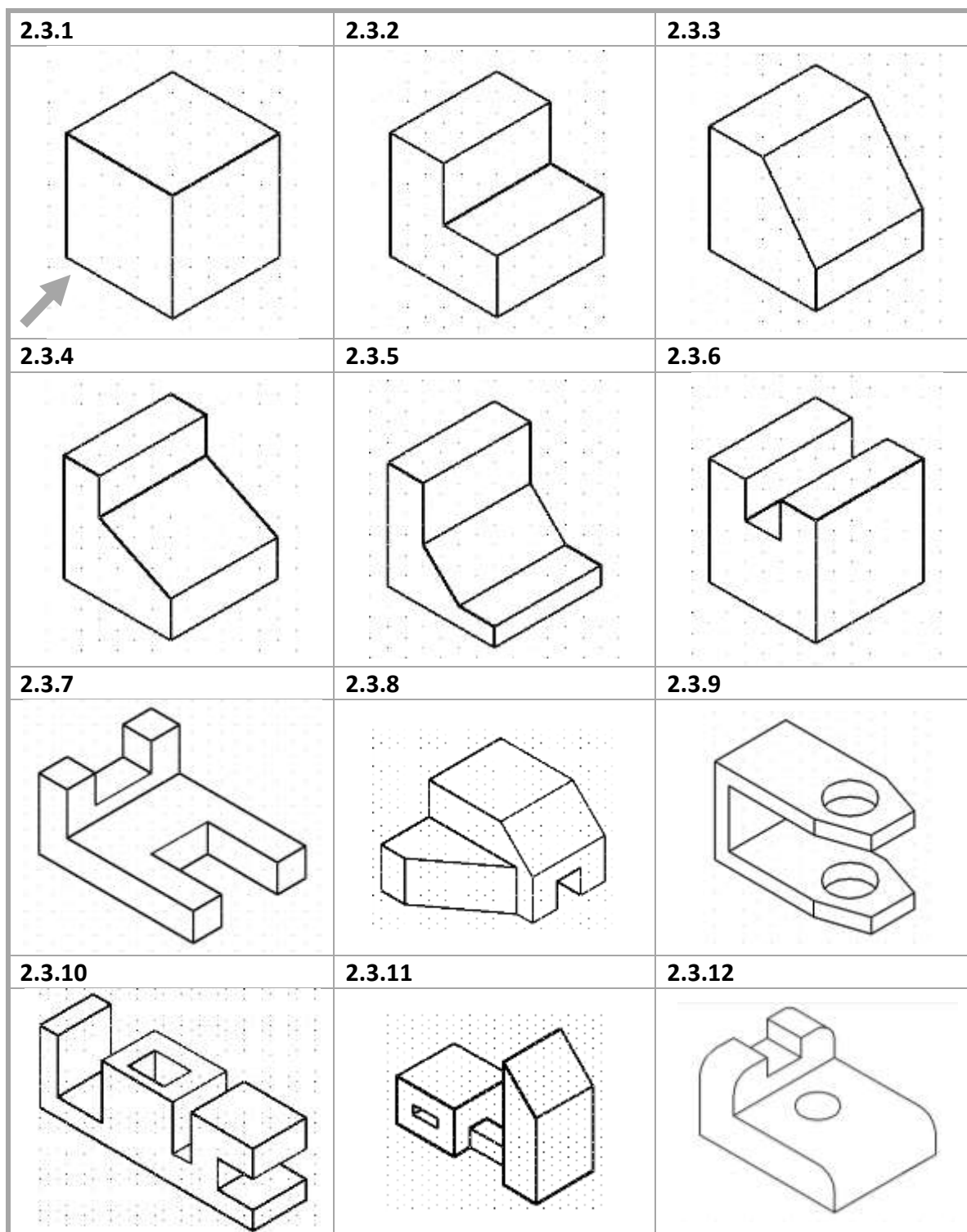
- identificação de todos os vértices (de A a J);
- projeção dos vértices em três planos perpendiculares, por exemplo no plano vertical, no plano horizontal e plano lateral;
- colocar as vistas de acordo com o método Europeu.



2.2 Desenhe o seguinte objeto.



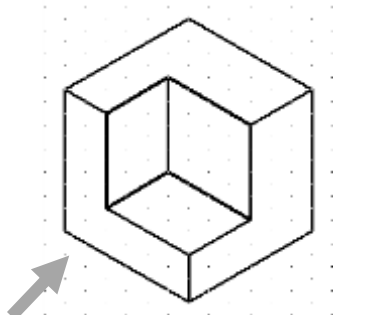
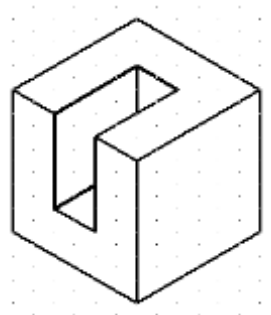
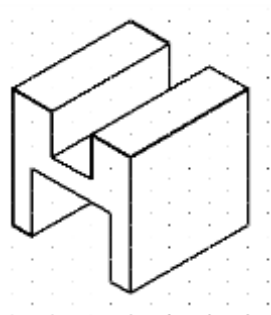
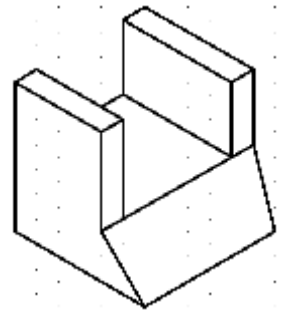
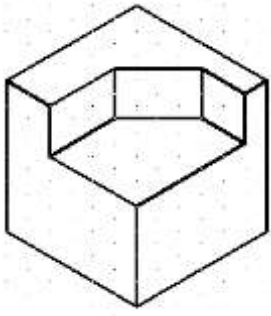
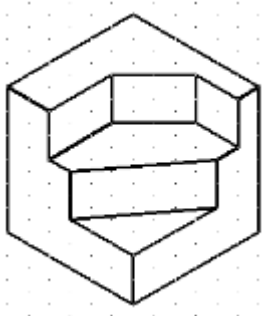
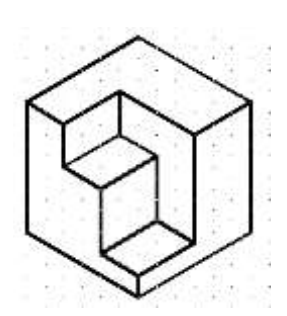
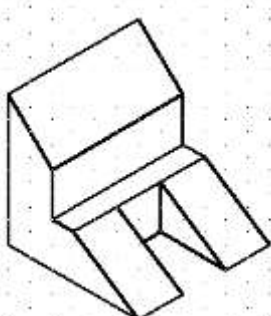
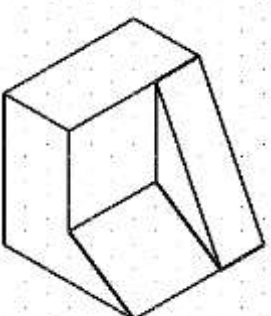
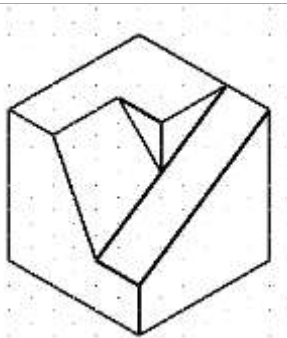
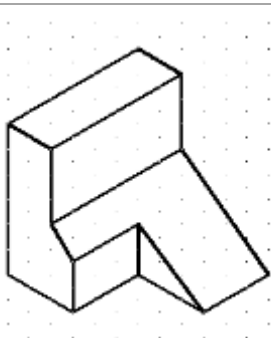
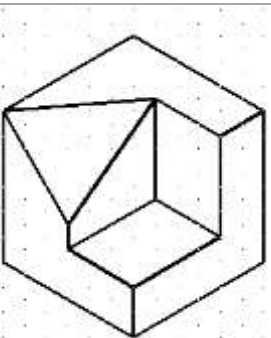
**2.3. Projeções ortogonais.** Desenhe, segundo o método Europeu, as projeções ortogonais necessárias para definir os objetos a seguir indicados (o espaçamento da grelha é 10 unidades e a seta a cinzento indica o alçado principal). Proceda à sua cotação num nível (layer) diferente daquele onde fez as projeções ortogonais, utilizando, por exemplo, a cor amarela.



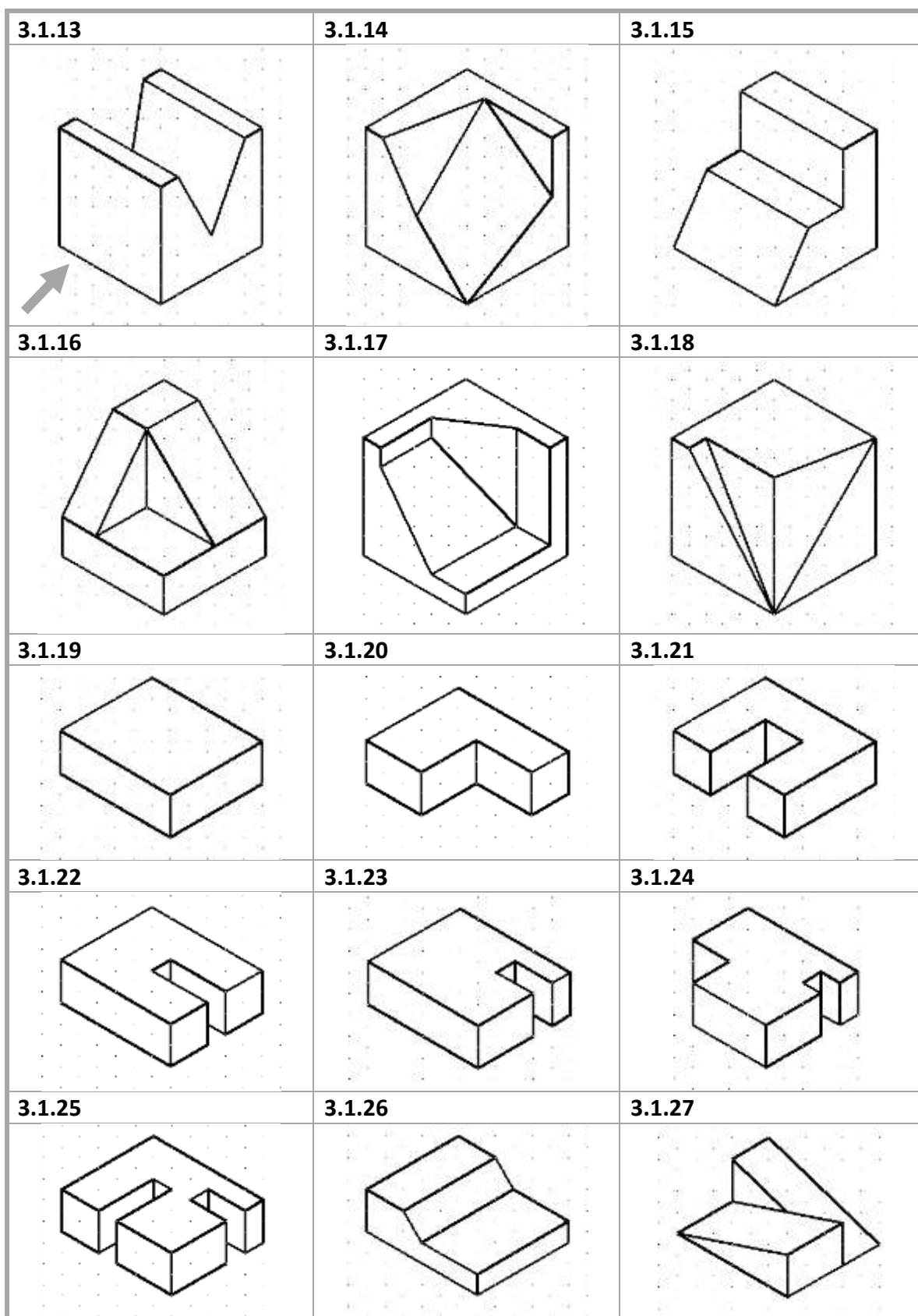


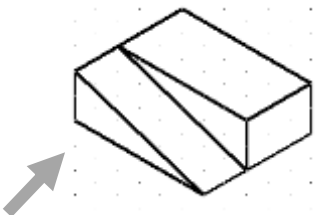
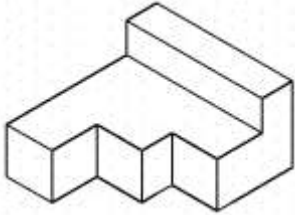
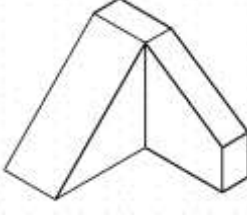
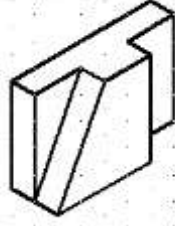
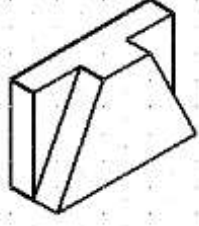
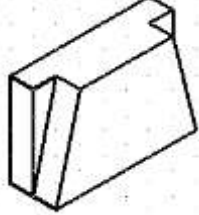
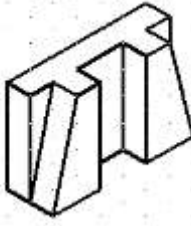
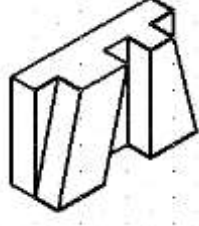
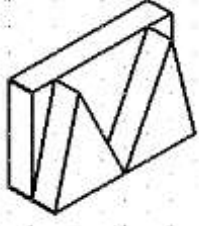
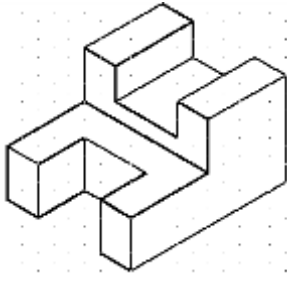
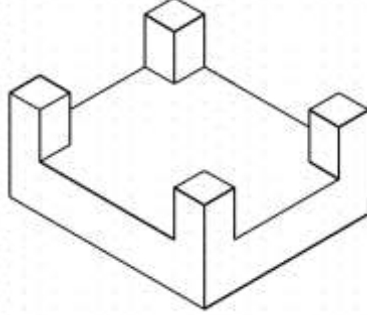
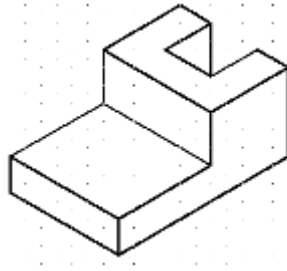
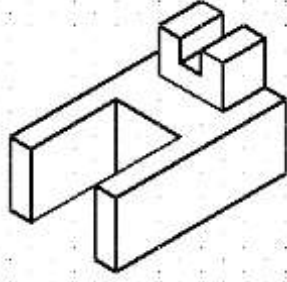
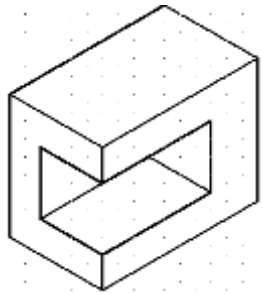
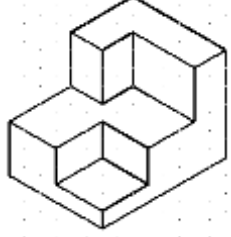
### 3. Exercícios de projeções ortogonais

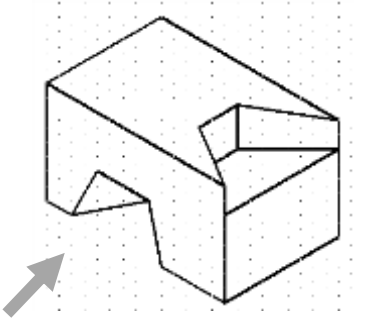
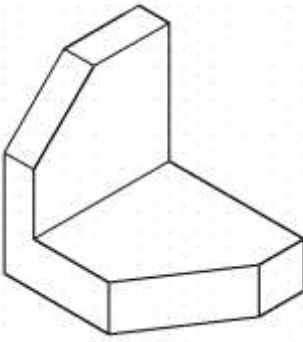
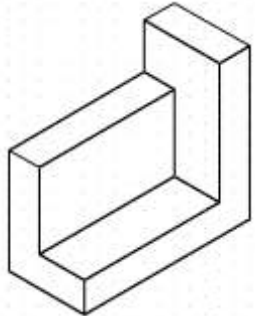
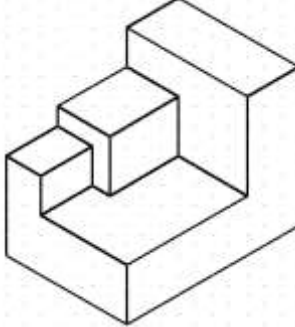
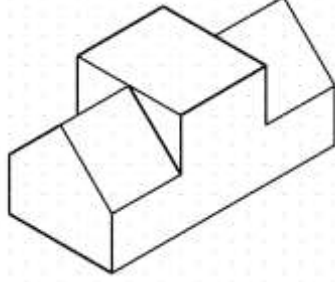
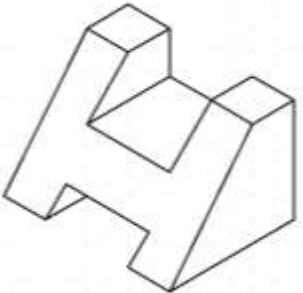
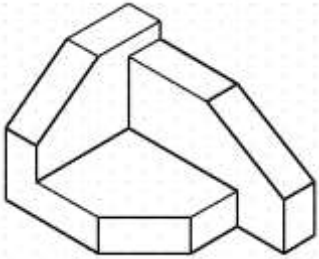
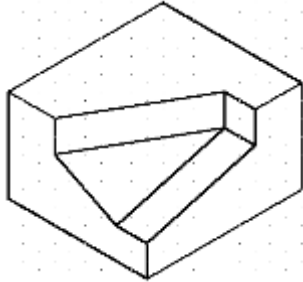
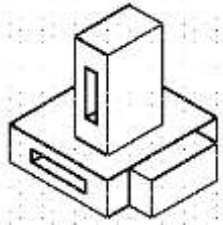
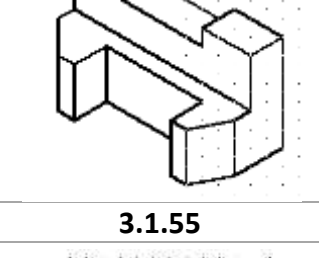
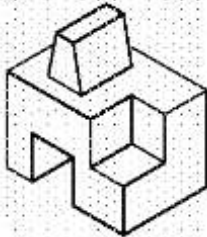
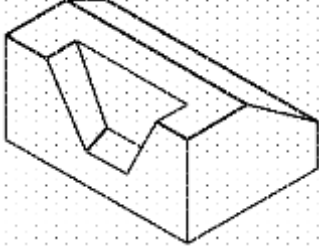
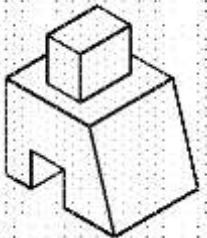
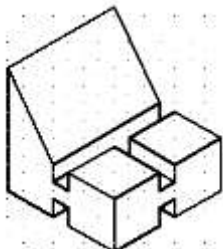
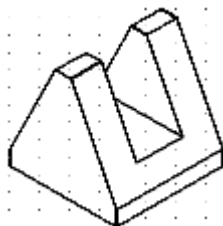
**3.1** Desenhe, segundo o método Europeu, as projeções ortogonais necessárias para definir os seguintes objetos (o espaçamento da grelha é 10 unidades e a seta a cinzento indica o alçado principal). Proceda à sua cotagem num nível (layer) diferente daquele onde fez as projeções ortogonais, utilizando, por exemplo, a cor amarela.

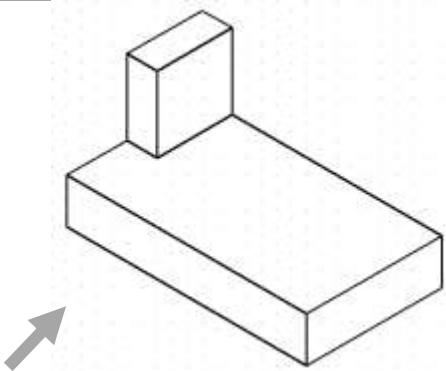
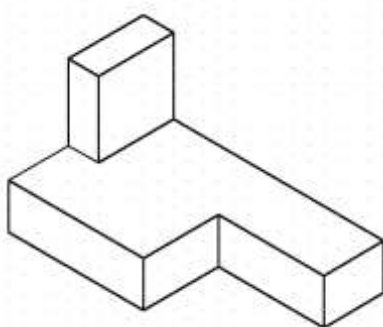
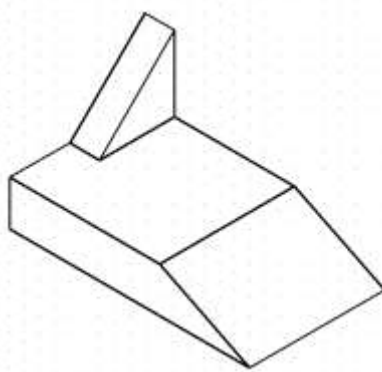
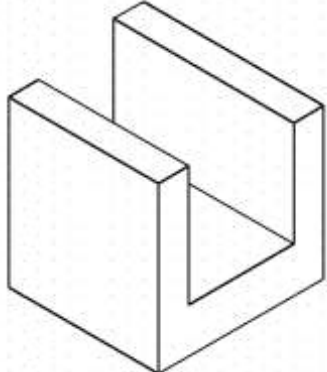
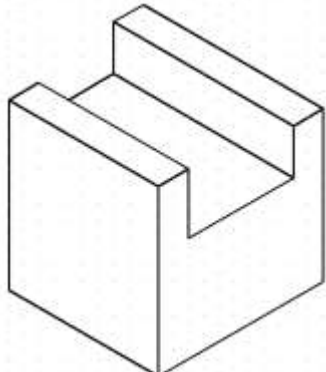
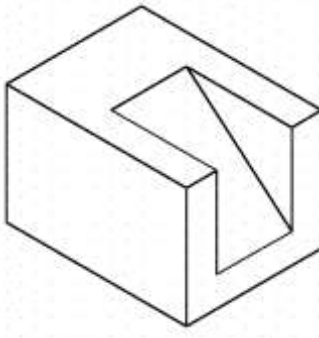
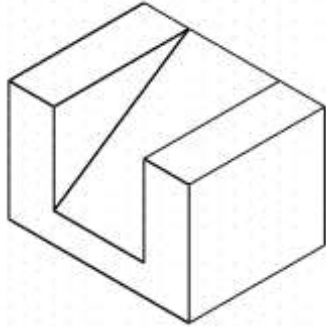
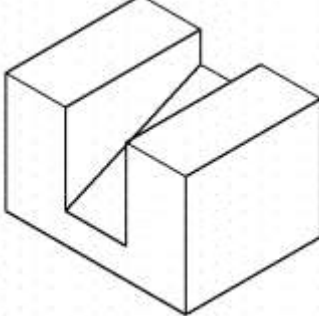
<b>3.1.1</b> 	<b>3.1.2</b> 	<b>3.1.3</b> 
<b>3.1.4</b> 	<b>3.1.5</b> 	<b>3.1.6</b> 
<b>3.1.7</b> 	<b>3.1.8</b> 	<b>3.1.9</b> 
<b>3.1.10</b> 	<b>3.1.11</b> 	<b>3.1.12</b> 

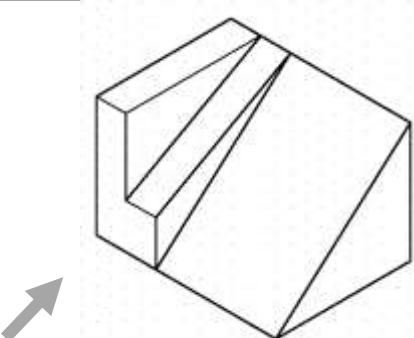
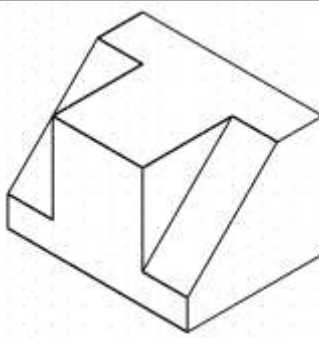
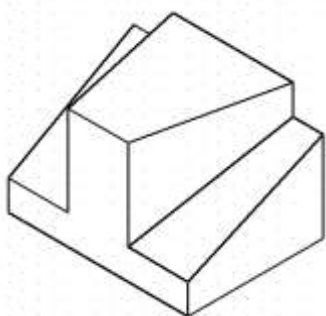
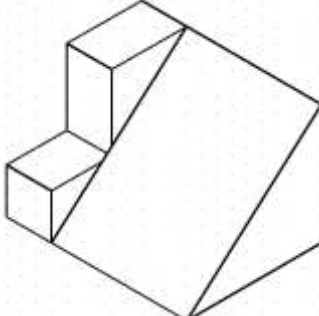
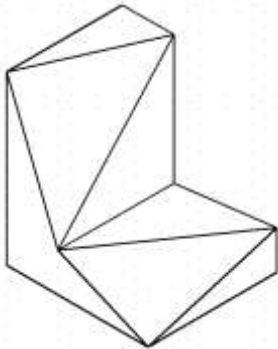
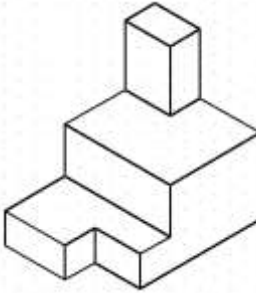
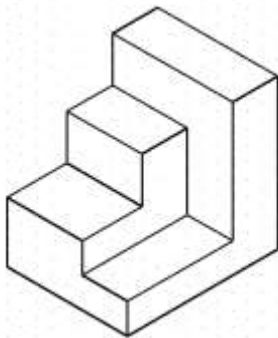
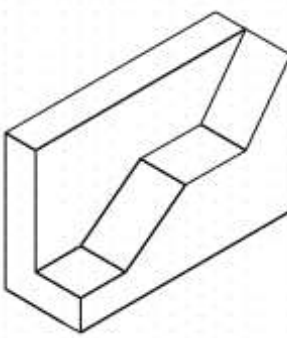




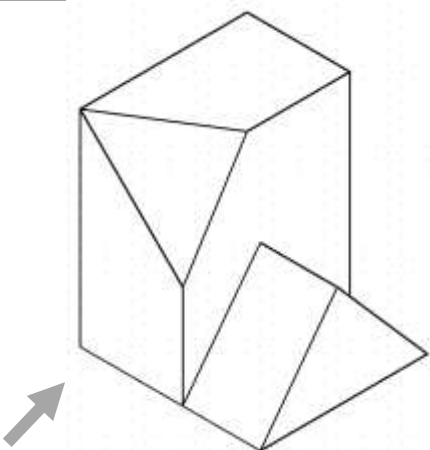
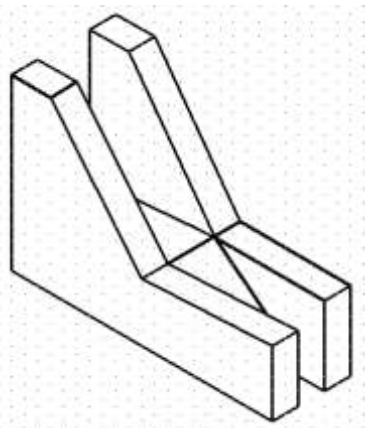
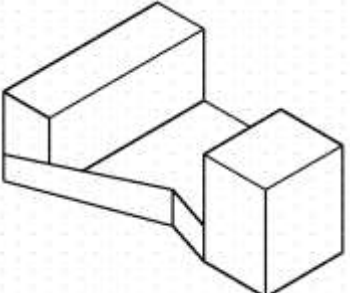
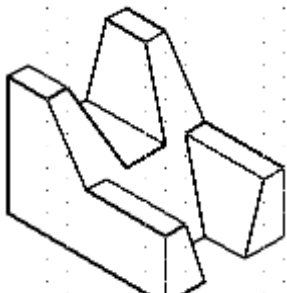

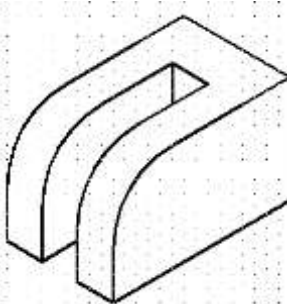
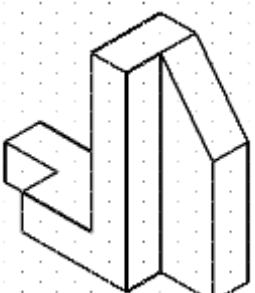
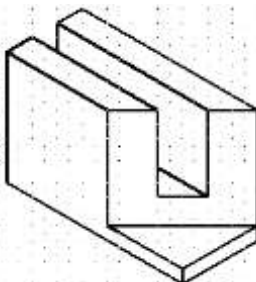
<b>3.1.28</b> 	<b>3.1.29</b> 	<b>3.1.30</b> 
<b>3.1.31</b> 	<b>3.1.32</b> 	<b>3.1.33</b> 
<b>3.1.34</b> 	<b>3.1.35</b> 	<b>3.1.36</b> 
<b>3.1.37</b> 	<b>3.1.38</b> 	<b>3.1.39</b> 
<b>3.1.40</b> 	<b>3.1.41</b> 	<b>3.1.42</b> 

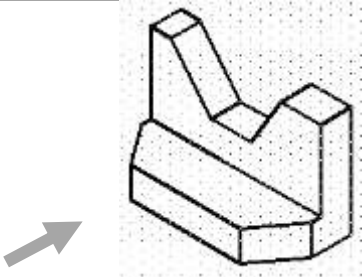
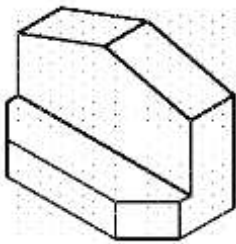
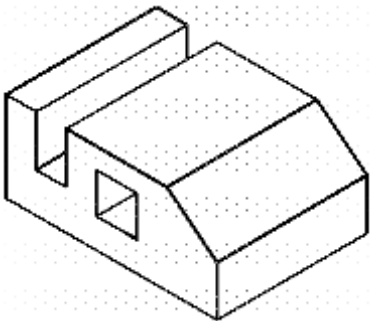
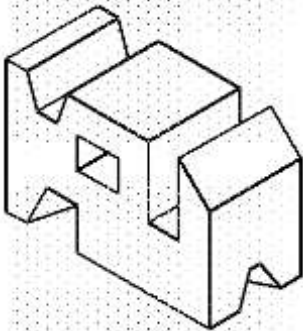
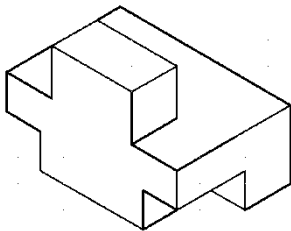
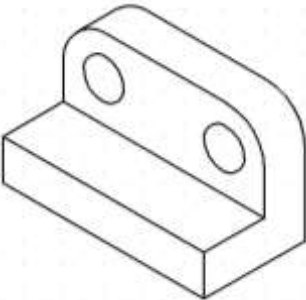
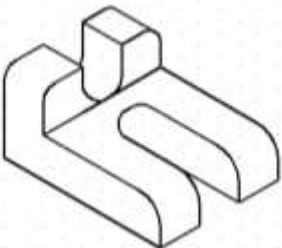
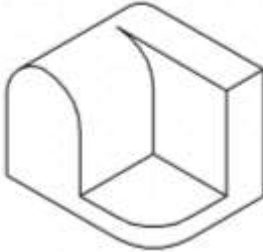
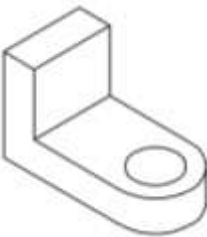
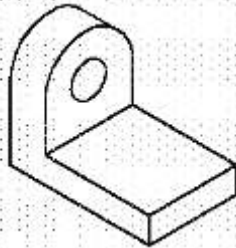
<b>3.1.43</b> 	<b>3.1.44</b> 	<b>3.1.45</b> 
<b>3.1.46</b> 	<b>3.1.47</b> 	<b>3.1.48</b> 
<b>3.1.49</b> 	<b>3.1.50</b> 	<b>3.1.51</b> 
<b>3.1.52</b> 	<b>3.1.53</b> 	<b>3.1.54</b> 
<b>3.1.55</b> 	<b>3.1.56</b> 	<b>3.1.57</b> 

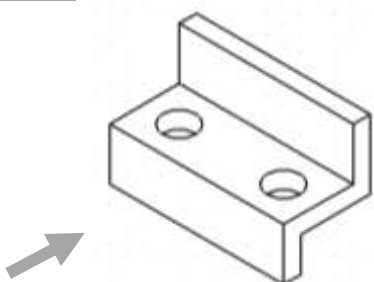
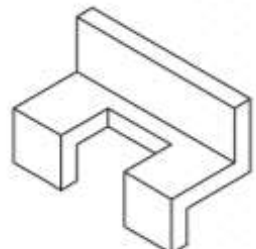
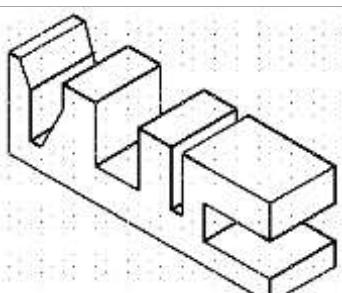
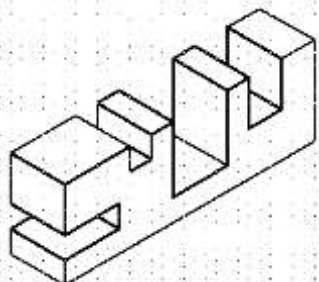
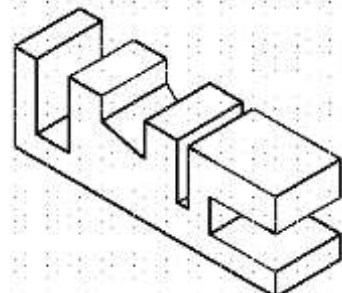
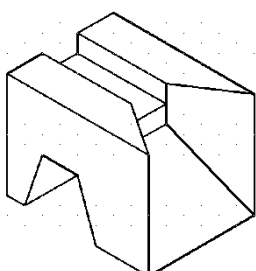
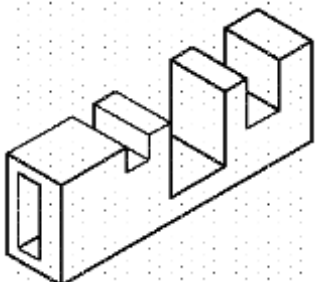
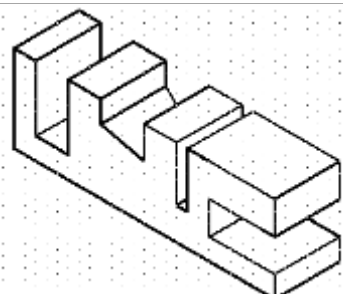
<b>3.1.58</b> 	<b>3.1.59</b> 
<b>3.1.60</b> 	<b>3.1.61</b> 
<b>3.1.62</b> 	<b>3.1.63</b> 
<b>3.1.64</b> 	<b>3.1.65</b> 

<b>3.1.66</b> 	<b>3.1.67</b> 
<b>3.1.68</b> 	<b>3.1.69</b> 
<b>3.1.70</b> 	<b>3.1.71</b> 
<b>3.1.72</b> 	<b>3.1.73</b> 



<b>3.1.74</b> 	<b>3.1.75</b> 
<b>3.1.76</b> 	<b>3.1.77</b> 
<b>3.1.78</b> 	<b>3.1.79</b> 
<b>3.1.80</b> 	<b>3.1.81</b> 

<b>3.1.82</b> 	<b>3.1.83</b> 
<b>3.1.84</b> 	<b>3.1.85</b> 
<b>3.1.86</b> 	<b>3.1.87</b> 
<b>3.1.88</b> 	<b>3.1.90</b> 
<b>3.1.100</b> 	<b>3.1.101</b> 

<b>3.1.102</b> 	<b>3.1.103</b> 
<b>3.1.104</b> 	<b>3.1.105</b> 
<b>3.1.106</b> 	<b>3.1.107</b> 
<b>3.1.108</b> 	<b>3.1.109</b> 



## III– Perspetivas

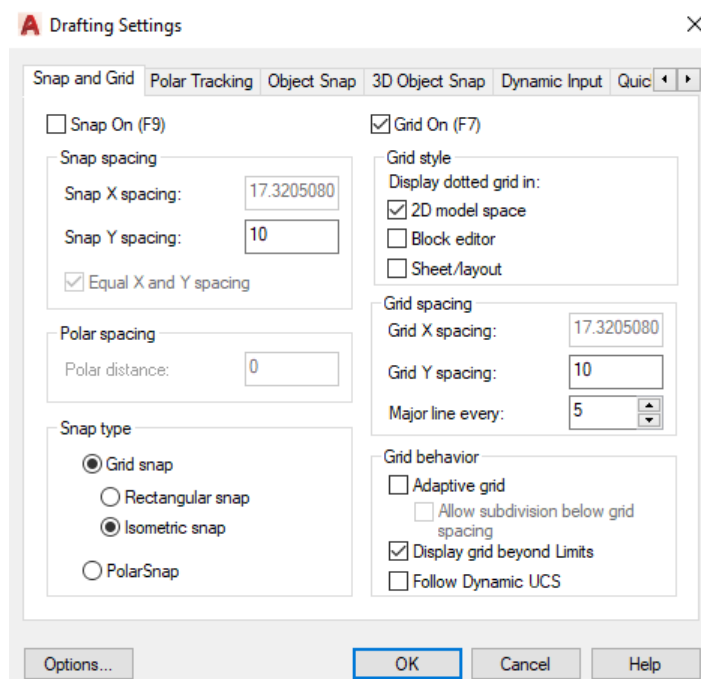
### Capacidades a adquirir nesta aula:

- a) Desenhar rigorosamente a perspetiva de qualquer objeto;
- b) Desenhar a perspetiva de um objeto a partir da sua representação em vistas múltiplas

### 1. Seleção de grelha isométrica

Na elaboração de uma perspetiva deve usar-se a grelha isométrica.

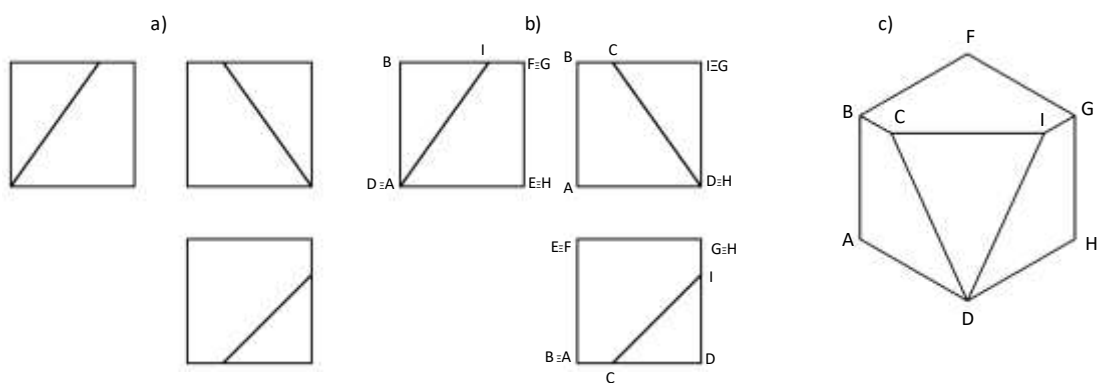
Ao colocar o cursor na barra de ferramentas inferior, clique no botão do lado direito do rato. Na janela que surge, clique em **Settings** e na janela **Drafting Settings** em **Snap type** selecione a instrução **Isometric snap**.



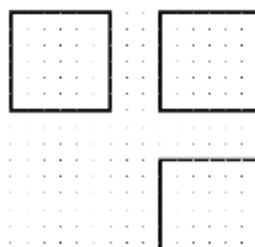
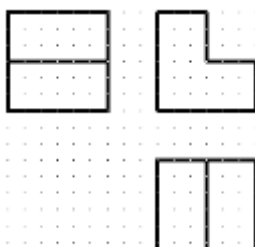
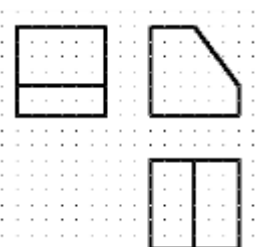
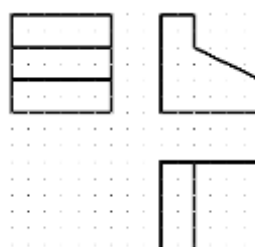
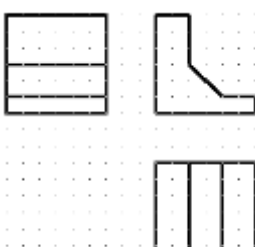
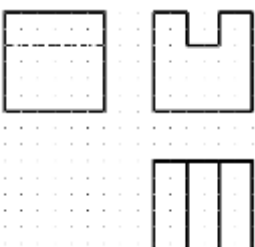
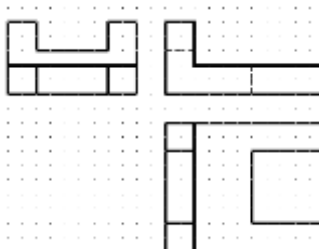
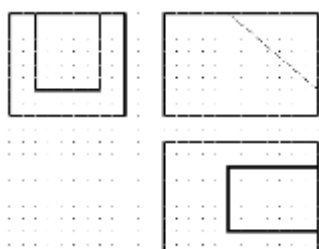
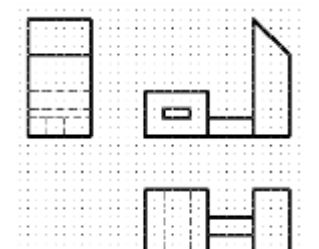
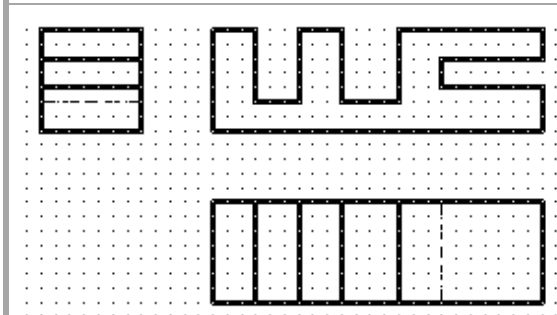
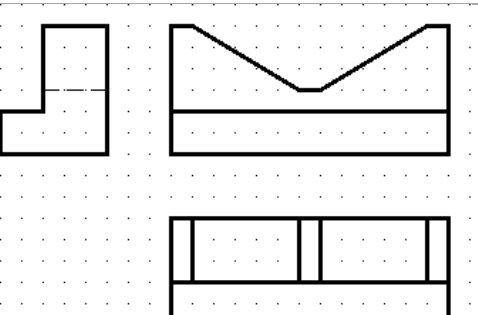
## 2. Ensino presencial

**2.1** Na visualização das vistas em volume haverá que ter em atenção a relação observador-objeto-plano de projeção. Assim, quando se analisa a planta deve ter-se a noção que se está a ver o objeto de cima, se for o alçado principal será de frente e se for o alçado lateral de lado. A partir da figura a) desenhe a sua perspectiva, de acordo com as indicações:

- identificar as vistas, na figura a);
- fazer a análise conjunta de duas vistas identificando as arestas comuns às duas e analisar todas as vistas em conjunto, para identificar todos os vértices e arestas;
- identificar de todos os vértices (de A a I) e arestas (figura b);
- desenhar os vértices e arestas ao longo dos eixos isométricos, obtendo-se assim a perspectiva (figura c)

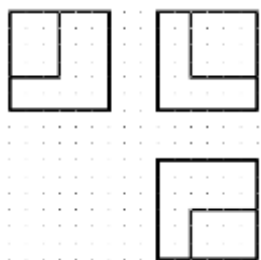
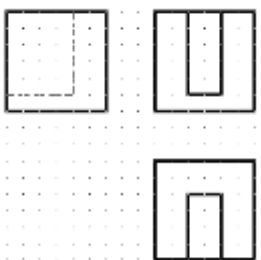
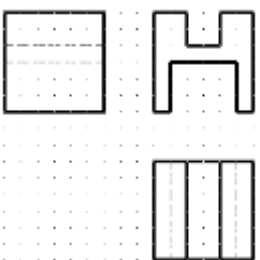
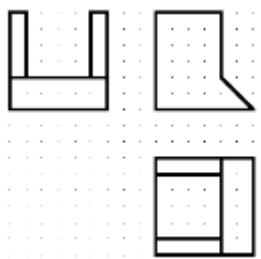
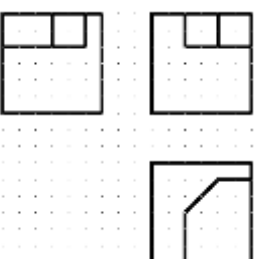
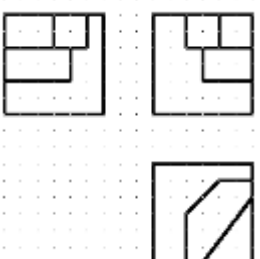
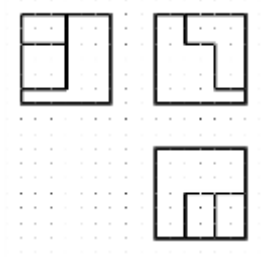
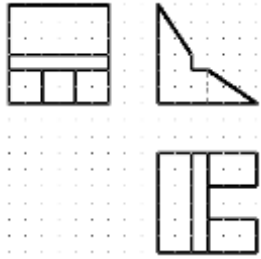
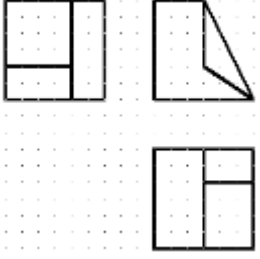
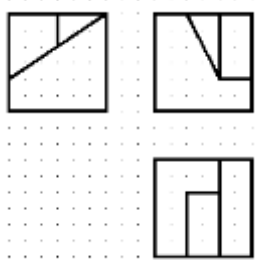
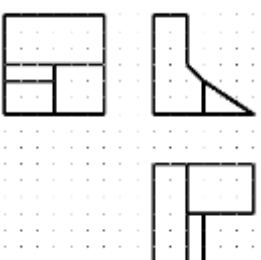
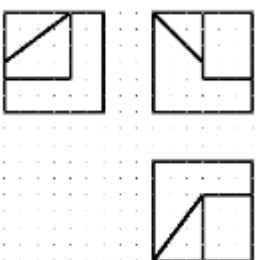
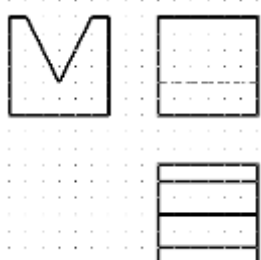
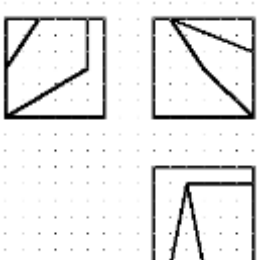
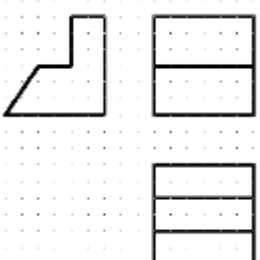


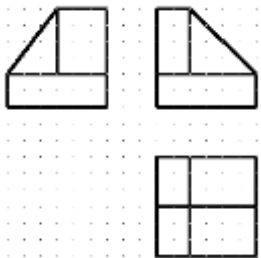
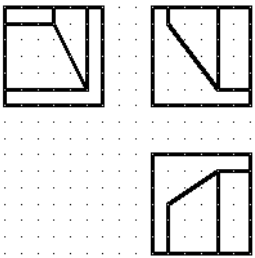
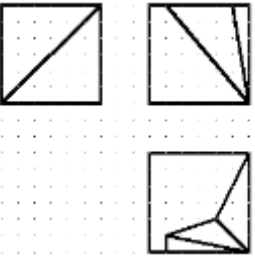
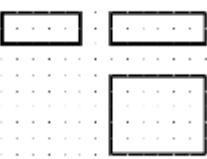
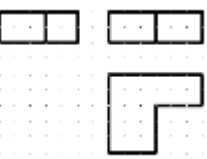
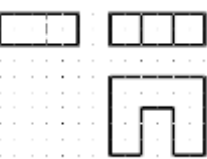
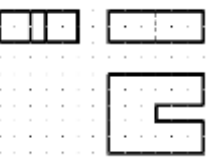
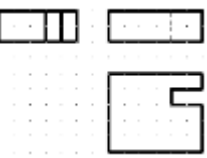
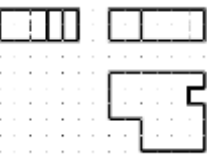
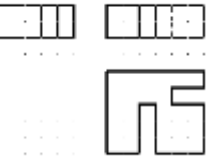
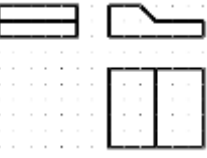
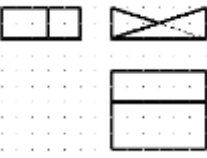




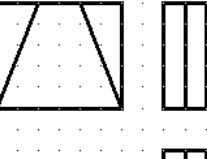
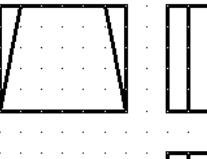
2.2 As figuras seguintes representam as projeções ortogonais de objetos. Desenhe cada um desses objetos em perspectiva axonométrica isométrica (o espaçamento da grelha é 10 unidades).

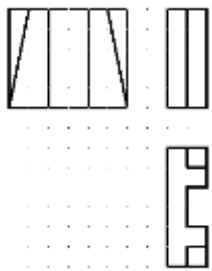
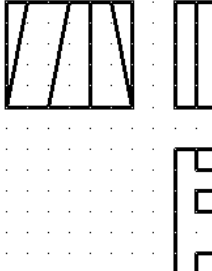

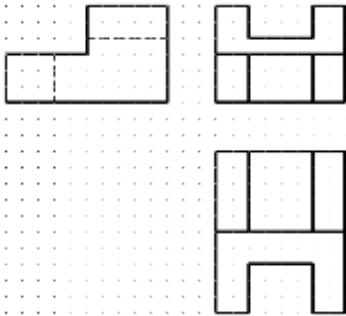
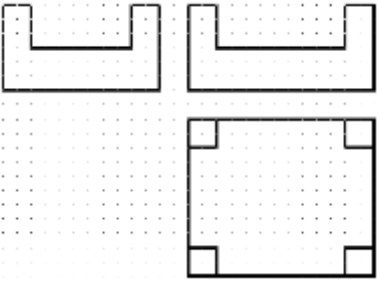
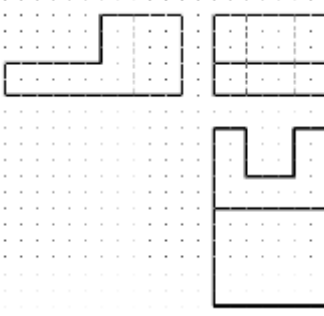
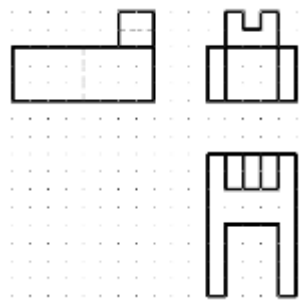
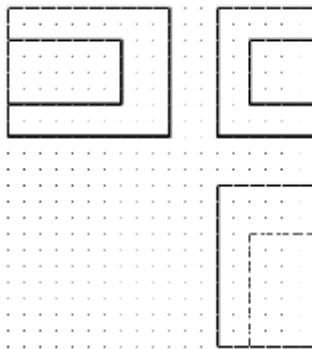
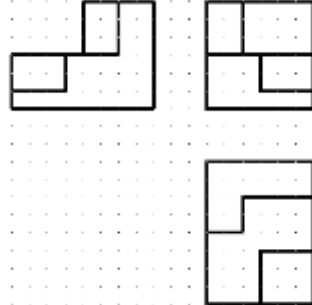
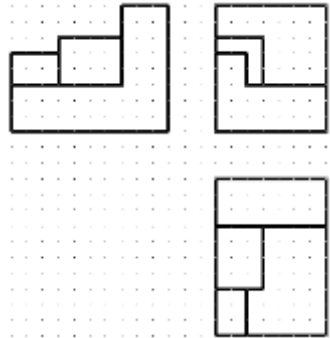
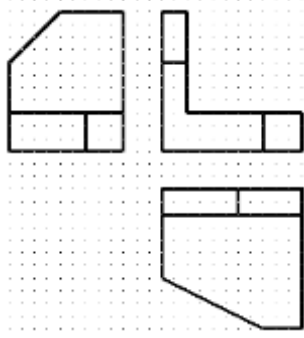
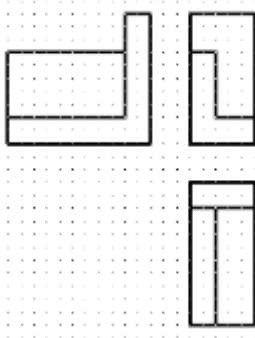
<b>2.2.1</b> 	<b>2.2.2</b> 	<b>2.2.3</b> 
<b>2.2.4</b> 	<b>2.2.5</b> 	<b>2.2.6</b> 
<b>2.2.7</b> 	<b>2.2.8</b> 	<b>2.2.9</b> 
<b>2.2.10</b> 		<b>2.2.11</b> 

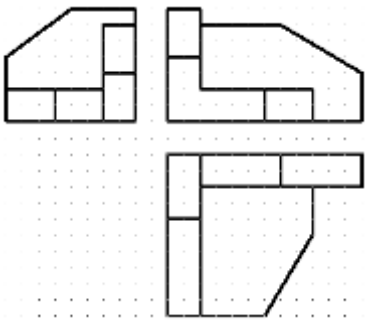
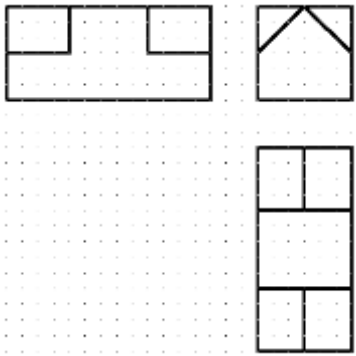
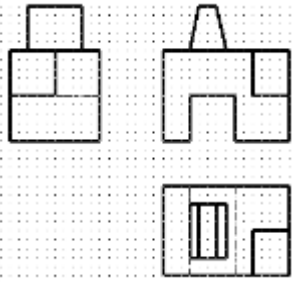
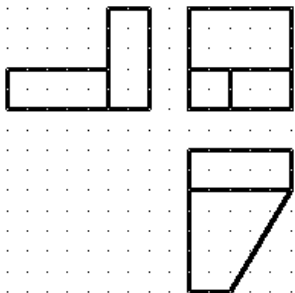
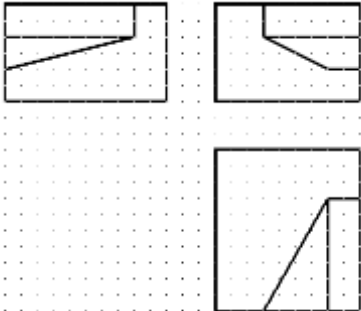
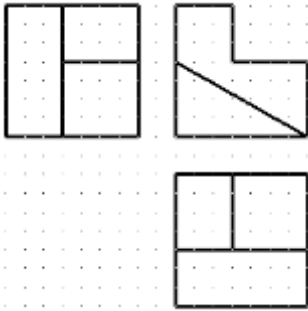
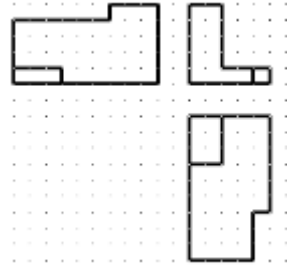
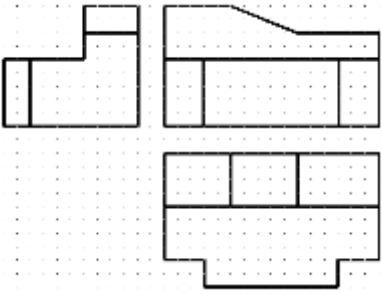
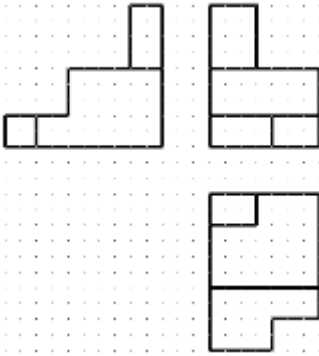
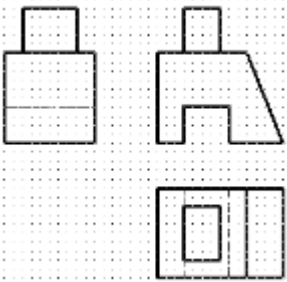
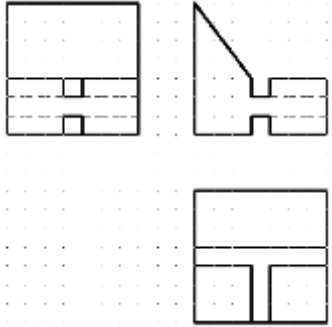
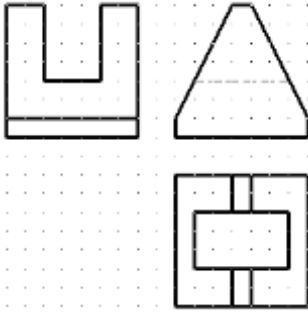
### 3. Exercícios de perspetivas

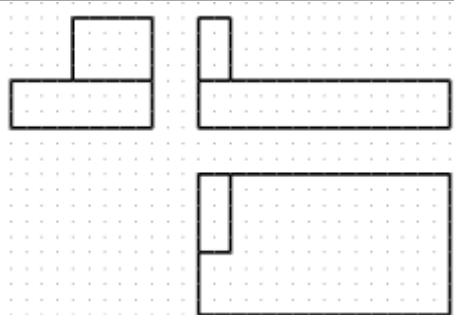
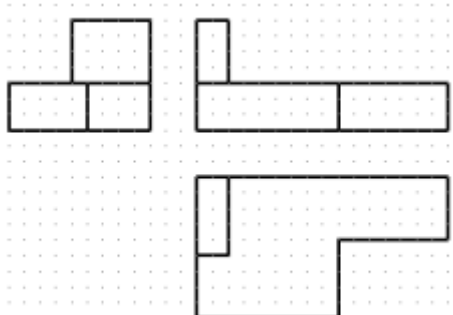
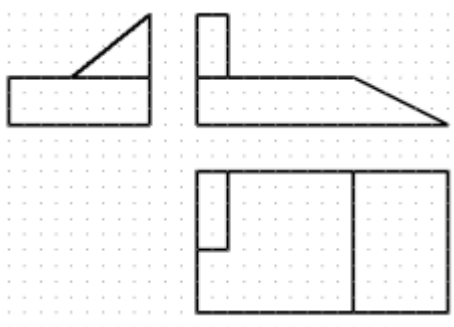
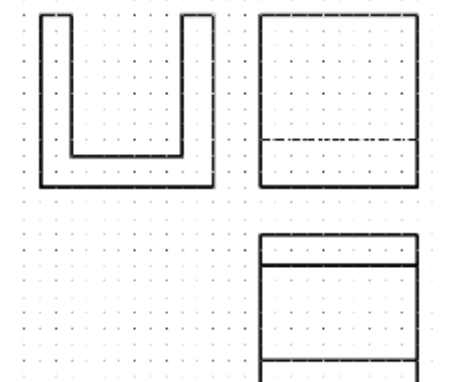
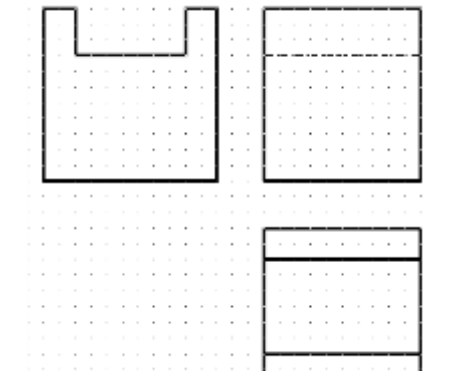
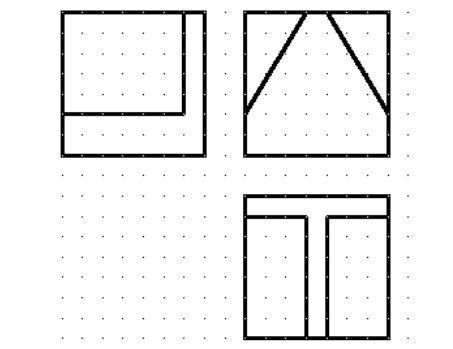
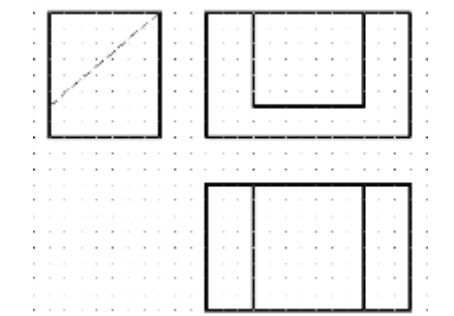
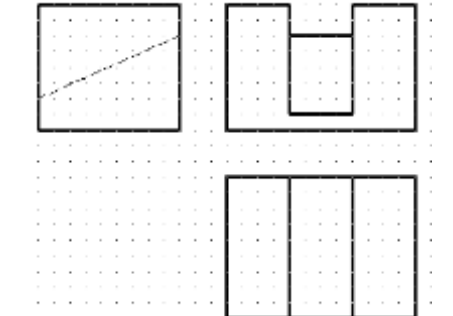
As figuras representam as projeções ortogonais de um objeto pelo método Europeu. Desenhe os objetos em perspetiva axonométrica isométrica (o espaçamento da grelha é 10 unidades).

<b>3.1.1</b> 	<b>3.1.2</b> 	<b>3.1.3</b> 
<b>3.1.4</b> 	<b>3.1.5</b> 	<b>3.1.6</b> 
<b>3.1.7</b> 	<b>3.1.8</b> 	<b>3.1.9</b> 
<b>3.1.10</b> 	<b>3.1.11</b> 	<b>3.1.12</b> 
<b>3.1.13</b> 	<b>3.1.14</b> 	<b>3.1.15</b> 

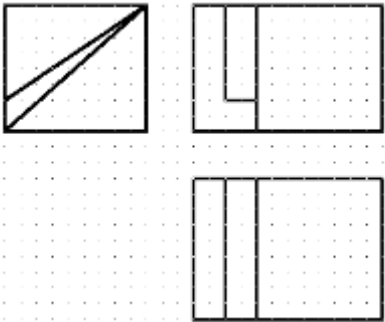
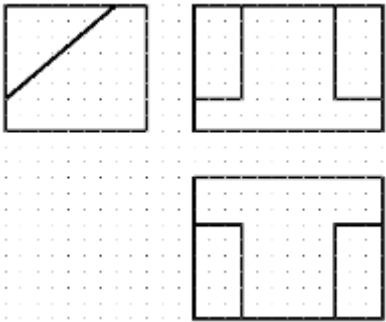
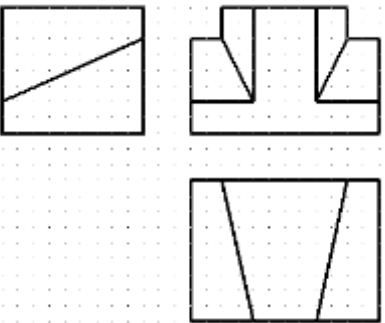
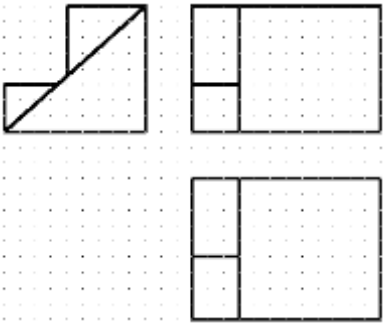
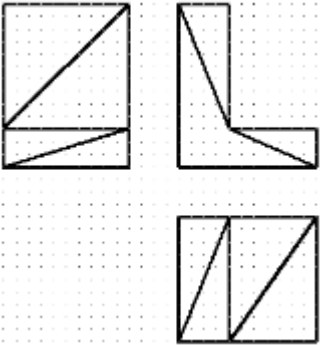
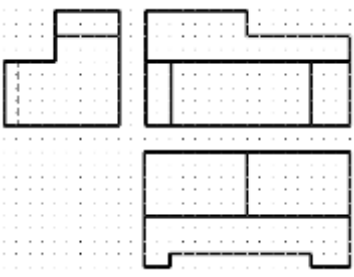
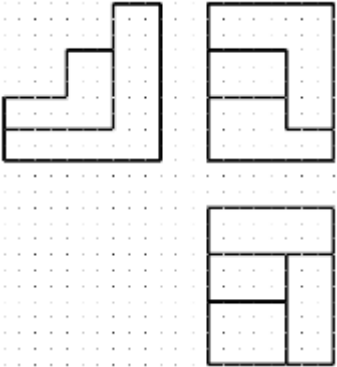
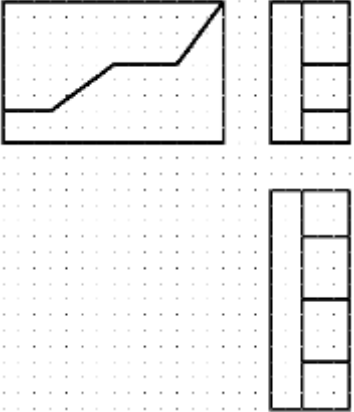
<b>3.1.16</b> 	<b>3.1.17</b> 	<b>3.1.18</b> 
<b>3.1.19</b> 	<b>3.1.20</b> 	<b>3.1.21</b> 
<b>3.1.22</b> 	<b>3.1.23</b> 	<b>3.1.24</b> 
<b>3.1.25</b> 	<b>3.1.26</b> 	<b>3.1.27</b> 
<b>3.1.28</b> 	<b>3.1.29</b> 	<b>3.1.30</b> 
<b>3.1.31</b> 	<b>3.1.32</b> 	<b>3.1.33</b> 

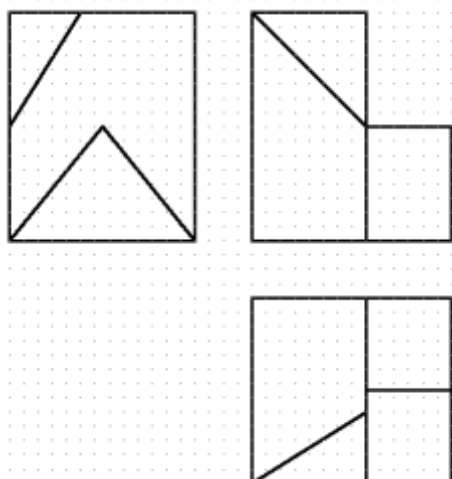
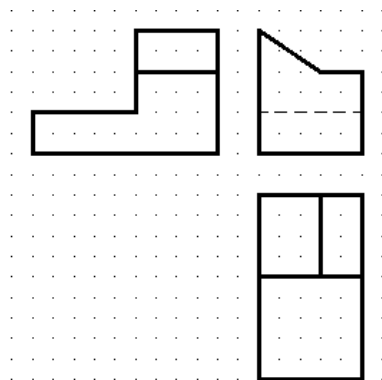
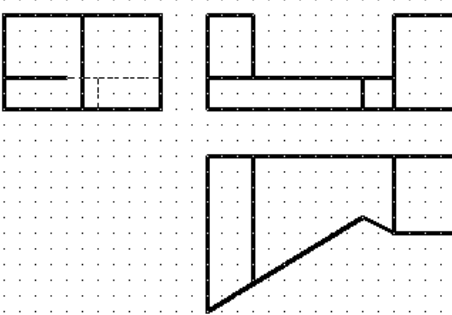
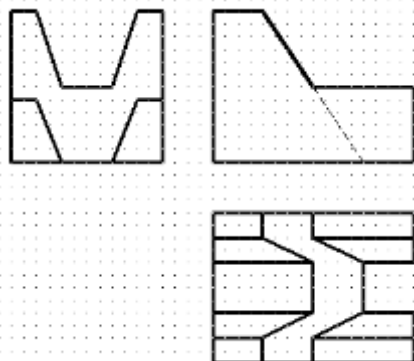
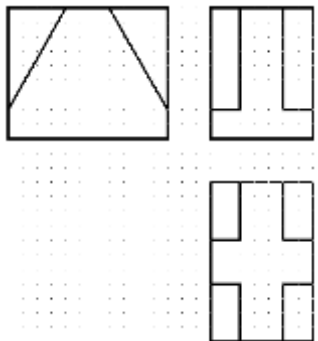
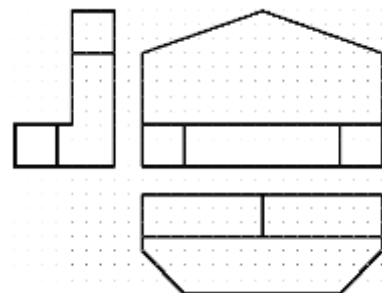
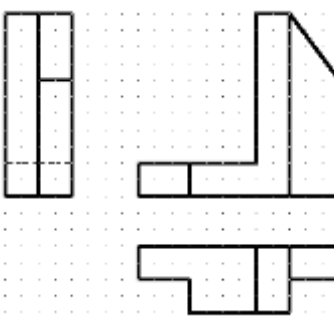
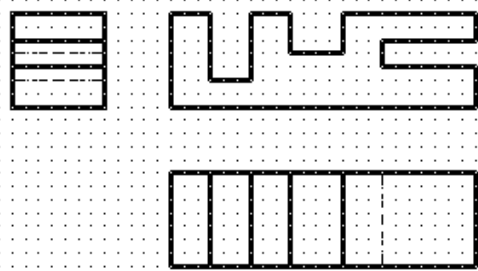
<b>3.1.34</b> 	<b>3.1.35</b> 	<b>3.1.36</b> 
<b>3.1.37</b> 	<b>3.1.38</b> 	<b>3.1.39</b> 
<b>3.1.40</b> 	<b>3.1.41</b> 	<b>3.1.42</b> 
<b>3.1.43</b> 	<b>3.1.44</b> 	<b>3.1.45</b> 

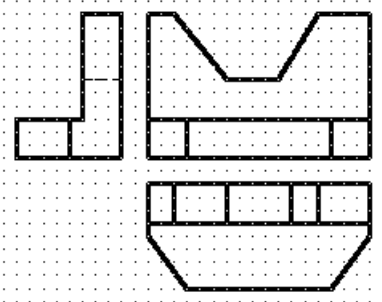
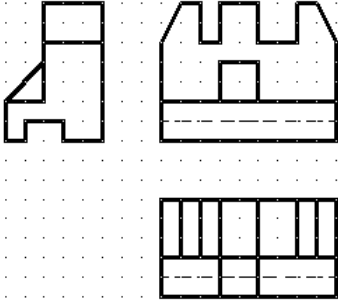
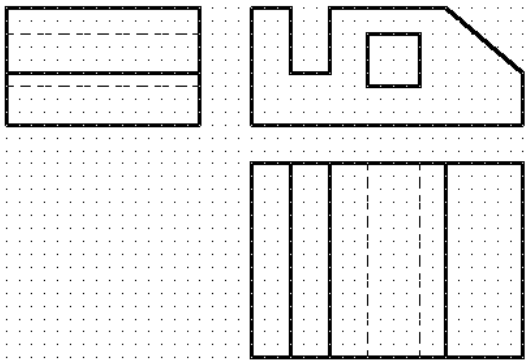
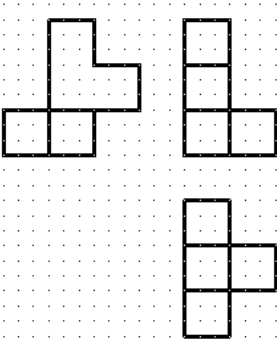
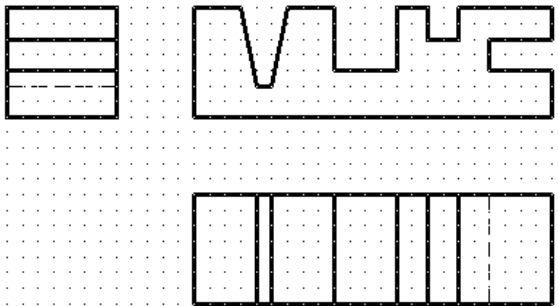
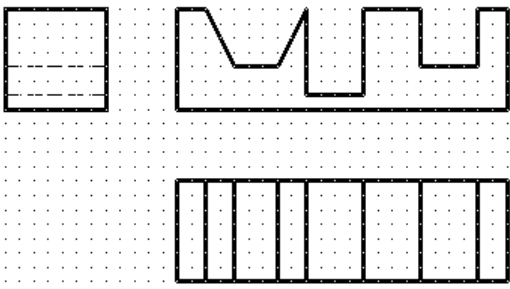
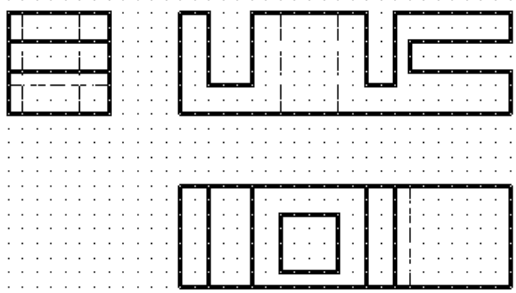
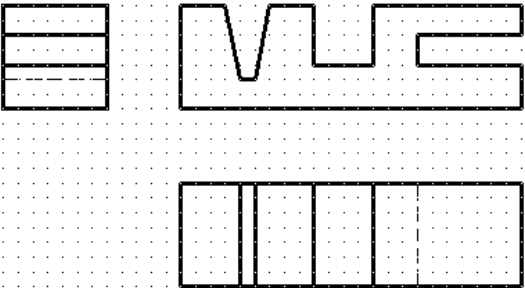
<b>3.1.46</b> 	<b>3.1.47</b> 	<b>3.1.48</b> 
<b>3.1.49</b> 	<b>3.1.50</b> 	<b>3.1.51</b> 
<b>3.1.52</b> 	<b>3.1.53</b> 	<b>3.1.54</b> 
<b>3.1.55</b> 	<b>3.1.56</b> 	<b>3.1.57</b> 

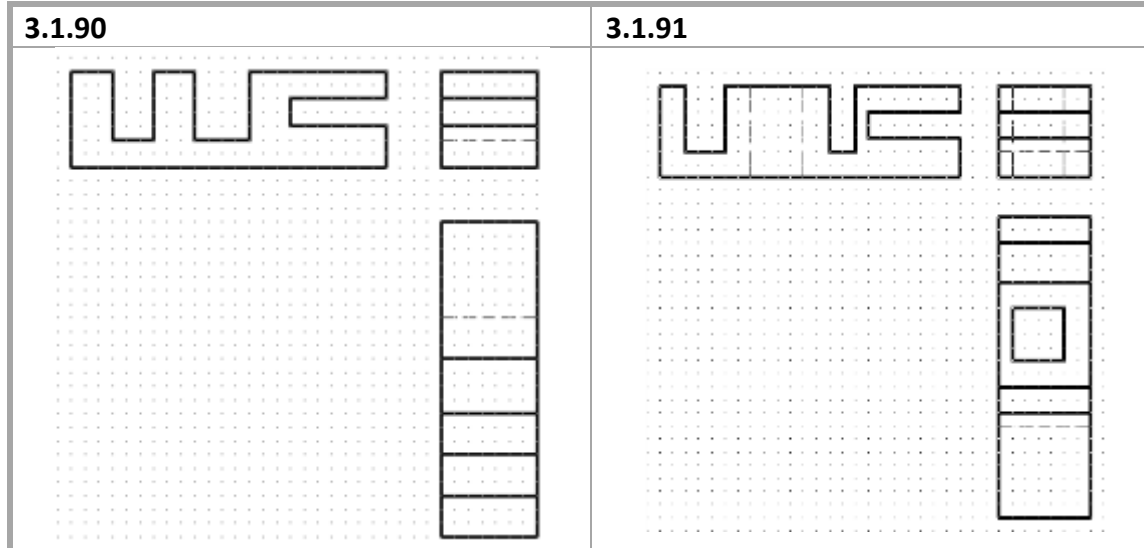
<b>3.1.58</b> 	<b>3.1.59</b> 
<b>3.1.60</b> 	<b>3.1.61</b> 
<b>3.1.62</b> 	<b>3.1.63</b> 
<b>3.1.64</b> 	<b>3.1.65</b> 



<p><b>3.1.66</b></p> 	<p><b>3.1.67</b></p> 
<p><b>3.1.68</b></p> 	<p><b>3.1.69</b></p> 
<p><b>3.1.70</b></p> 	<p><b>3.1.71</b></p> 
<p><b>3.1.72</b></p> 	<p><b>3.1.73</b></p> 

**3.1.74**

**3.1.75**

**3.1.76**

**3.1.77**

**3.1.78**

**3.1.79**

**3.1.80**

**3.1.81**


<b>3.1.82</b> 	<b>3.1.83</b> 
<b>3.1.84</b> 	<b>3.1.85</b> 
<b>3.1.86</b> 	<b>3.1.87</b> 
<b>3.1.88</b> 	<b>3.1.89</b> 



## IV – Desenho a três dimensões, cortes e secções

**Capacidades a adquirir nesta aula:**

### Aspetos complementares de desenho a 2D

- a) Saber abrir e ocultar os vários TOOLBARS.
- b) Utilizar MULTILINE;
- c) Modificar objetos desenhados utilizando EXPLODE;
- d) Editar Poli-linhas.

### Construção de peças a 3D

- a) Transformar linhas e arcos em poli-linhas;
- b) Utilizar os comandos REVOLVE e EXTRUDE para obter objetos 3D simples;
- c) Utilizar várias janelas e pontos de vista (VIEWPOINT).

### Cortes e secções

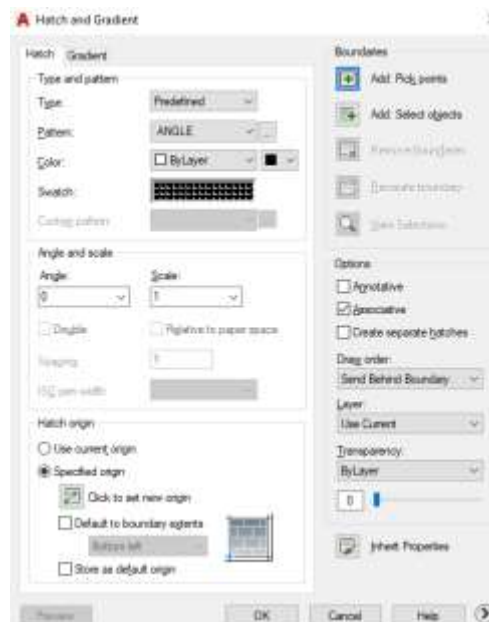
- a) Saber as normas de desenho de cortes e secções;
- b) Decidir sobre a necessidade de recorrer a cortes ou secções para representar completamente uma peça em projeções ortogonais;
- c) Saber optar entre um corte ou uma secção;
- d) Optando por um corte, selecionar o mais adequado;

### **1. Aspetos complementares do desenho a 2D**

Na barra de ferramentas **Draw** o ícone **Hatch**,  permite preencher uma área com um determinado padrão. Após a seleção do ícone **Hatch**:

Pick internal point or [Select objects/Undo/Settings]: **t**

Surge uma janela.




Selecione o padrão pretendido em **Pattern**. Com exceção do padrão **Solid**, deve também selecionar o ângulo (**Angle**) e a escala (**Scale**) pretendida, tendo o cuidado na sua adequação à dimensão do

desenho. Para preenchimento da área deve selecionar em **Boundaries**, **Add: Pick points** ou **Add: Select objects**. Clique na zona do desenho pretendida e faça **OK**.

## 2. Transformação de linhas e arcos em poli-linhas

### Toolbar **Modify II**



Para transformar linhas e arcos em poli-linhas seleccione **Edit polyline**, , na barra de ferramentas “Modify II”. Esta tarefa executa-se seguindo as instruções da linha de comando, podendo ser efetuada de duas formas (Opções A e B). Para cada opção indica-se com letra normal as instruções da linha de comando e indica-se com letra a negrito as respostas a colocar na referida linha de comando. As linhas e os arcos devem intersestar-se e não deve haver linhas sobrepostas para se fechar a poli-linha.

#### 2.1. Opção A

Select polyline or [Multiple]:

**Clicar em cima de uma linha ou arco do objeto**

Object selected is not a polyline

Do you want to turn it into one? <Y> **y**

Enter an option [Close/Join/Width/Edit vertex/Fit/Spline/Decurve/Ltype gen/Reverse/Undo]: **j**

Select objects:

**Selecione as linhas e arcos**

**enter**

#### 2.2 Opção B

Select polyline or [Multiple]:**m**

**enter**

Select objects:

**Selecione as linhas e arcos**

**enter**

Convert Lines, Arcs and Splines to polylines [Yes/No]? **Y**

**enter**

Enter an option [Close/Open/Join/Width/Fit/Spline/Decurve/Ltype gen/Reverse/Undo]: **J**

**enter**

Enter fuzz distance or [Jointype] <0.000>: **0**

**enter**

Enter an option [Close/Open/Join/Width/Fit/Spline/Decurve/Ltype gen/Reverse/Undo]: **C**

**enter**

**enter**

### 3. Desenho a 3D

A barra **View** permite a visualização do objeto a duas ou três dimensões. Na visualização a 2D pode optar por desenhar na vista de cima (**Top**), na vista de baixo (**Bottom**), na vista da esquerda (**Left**), na vista da direita (**Right**), na vista da frente (**Front**) ou na vista de trás (**Back**). Na visualização a 3D poderá optar pela vista **SW isometric**, **SE isometric**, **NE isometric** ou **NW isometric**.

Antes de iniciar a elaboração de um objeto a 3D, deve seleccionar, na barra de ferramentas **View**, a vista a duas dimensões mais adequada.

Toolbar **View**



Toolbar **Modelling**




Toolbar **Render**



A ferramenta **Modelling** permite a elaboração de objetos a três dimensões, com as instruções *Box*, *Wedge*, *Pyramid*, *Sphere*, *Cylinder*, *Torus*, *Pyramid* e *Helix*. Após clicar na instrução deverá seguir os passos indicados na linha de comandos.

Os objetos a 3D podem também ser construídos a partir de desenhos a 2D com as instruções **Revolve** ou **Extrude**. Com esta instrução devem construir-se os objetos a 2D e usar a ferramenta **Edit polyline** para fechar os polígonos.


A instrução **Revolve**  usa-se quando se pretende construir um objeto a 3D a partir da sua projeção e de um eixo de simetria. Devem seguir-se os seguintes passos, que se encontram na ferramenta de comando:

select objects to revolve: **selecione o objeto**

Specify axis start point or define axis by [Object/X/Y/Z] <Object>: **Com o rato defina o eixo selecionando o primeiro ponto que define um segmento de reta**

Specify axis endpoint: **Com o rato defina o eixo selecionando o segundo ponto que define um segmento de reta**

Specify angle of revolution or [Start angle] <360>: **360**

A instrução **Extrude**  usa-se quando se pretende construir um objeto a 3D a partir da sua projeção e de uma direção perpendicular à da projeção. Devem seguir-se os seguintes passos, que se encontram na ferramenta de comando:

Select objects to extrude: **selecione o objeto**

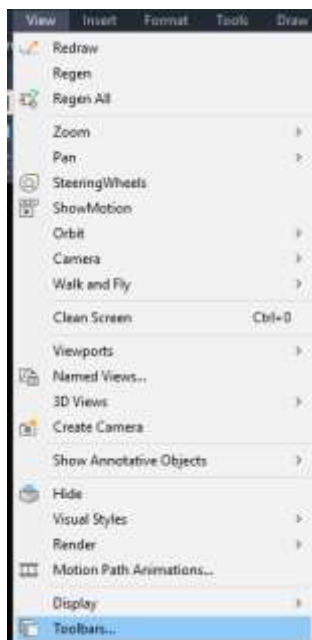
Specify height of extrusion or [Direction/Path/Taper angle] <23.521>: **Indique a altura de extrusão**



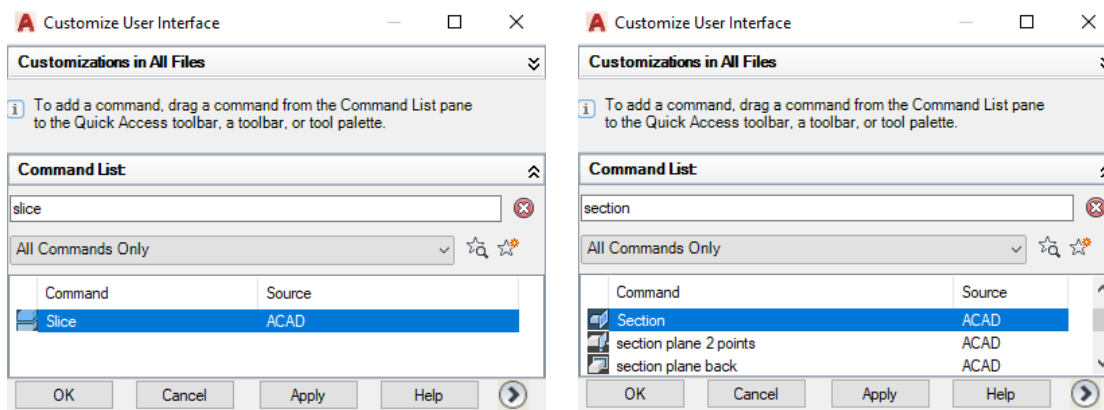
#### 4. Colocação das ferramentas slice e section na barra Modelling


Os comandos para efetuar os cortes e as secções não se encontram incluídos em nenhuma barra. No entanto, poderá colocar estas duas operações na barra **Modelling**, procedendo do seguinte modo:

No menu **View** abrir o menu **Toolbars**




Abre uma nova janela, **Customizations User in All Files**, na qual se vai seleccionar a instrução **Slice**. Arrasta-se para o menu **Modelling** e faz-se **Apply** na janela **Customizations User in All Files**.



A barra **Modelling** ficará com a instrução de **Slice** .



Procede-se do mesmo modo para adicionar a instrução **Section** .




A instrução **Slice** permite gerar cortes em objetos 3D. Para fazer os cortes devem seguir-se as seguintes instruções:

Criar uma layer (Corte) com cor diferente da layer de desenho do objeto

Copiar o objeto para a layer corte

Ativar o OSNAP

Selecionar **Slice** , na ferramenta de comando

Select objects to slice: **selecionar o objeto**

**enter**

Specify start point of slicing plane or [planar Object/Surface/Zaxis/View/XY/YZ/ZX/3points]

<3points>: **selecionar um semiplano, XY ou YZ ou ZX**

**enter**

Specify a point on the XY-plane <0,0,0>: **selecionar um ponto no objeto 3D**


Specify a point on desired side or [keep Both sides] <Both>: **b**

Apagar o corte em que não se vê o seu interior

A instrução **Section** permite gerar seções em objetos 3D. Para fazer os cortes devem seguir-se as seguintes instruções:

Criar uma layer (Secao) com cor diferente da layer de desenho do objeto

Ativar o OSNAP

Selecionar **Section** , na ferramenta de comando

Select objects to slice: **selecionar o objeto**

**enter**

Specify start point of slicing plane or [planar Object/Surface/Zaxis/View/XY/YZ/ZX/3points]

<3points>: **selecionar um semiplano, XY ou YZ ou ZX**

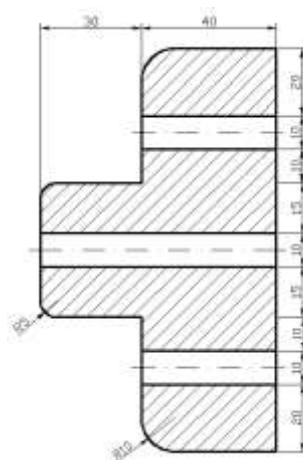
**enter**

Specify a point on the XY-plane <0,0,0>: **selecionar um ponto no objeto 3D**

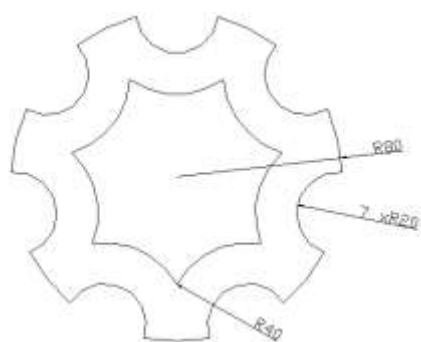
Formatar a seções em função das regras (cf. Apontamentos teóricos de Desenho Técnico Assistido por Computador).

## 5. Ensino presencial

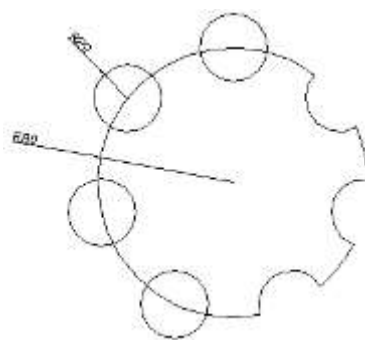
5.1 Desenhe a seguinte vista cortada. O espaçamento da grelha é 10 unidades.



5.2 Para desenhar o seguinte objeto, pode desenhar apenas a parte exterior e utilizar o comando *offset* (25 mm) para obter a parte interior. No entanto para poder fazer isso, primeiro precisa de transformá-lo numa poli-linha.




Desenho final

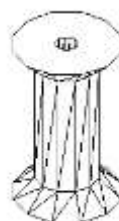
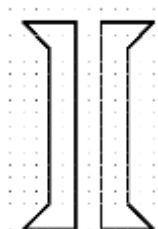


Desenho intermédio

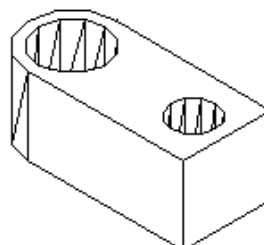
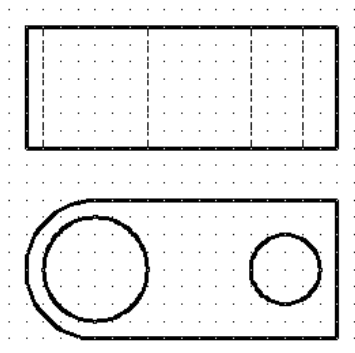
5.3 Desenhe os seguintes objetos a 3 dimensões. Faça os cortes e as secções segundo a vertical e a horizontal, que achar mais conveniente, selecionando o plano mais adequado.

**Nota:** de modo a visualizar melhor o objeto a 3 dimensões, após a sua construção aplique o comando **HIDE**.

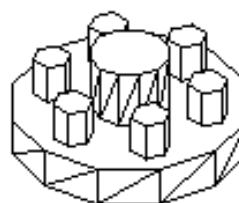
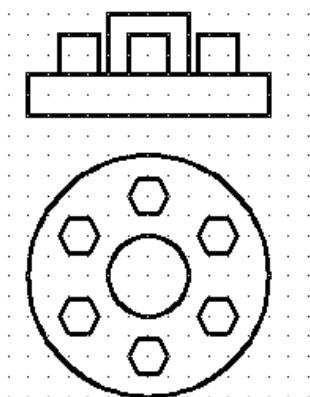
5.3.1 Carrinho de linhas. A secção do objeto, passando pelo eixo central está apresentada na figura seguinte (o espaçamento da grelha é 10 unidades). Use o comando  **REVOLVE**.



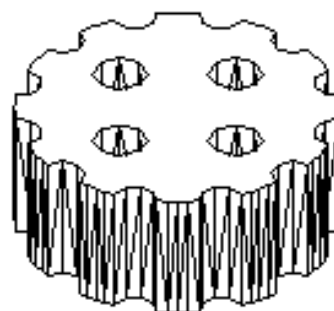
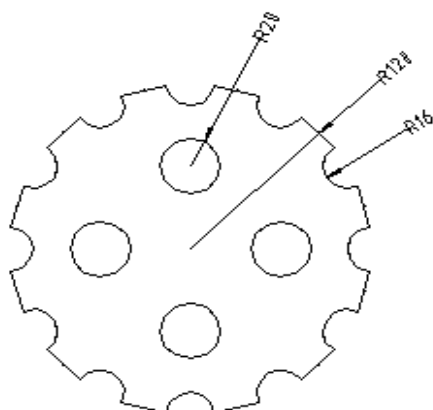
**5.3.2** Desenhe a peça seguinte de acordo com as indicações fornecidas (o espaçamento da grelha é 10 unidades). Transforme-o numa placa com 50 de altura utilizando **EXTRUDE**, . Desenhe dois cilindros com 60 de altura na placa. Em seguida subtraia os cilindros da placa .



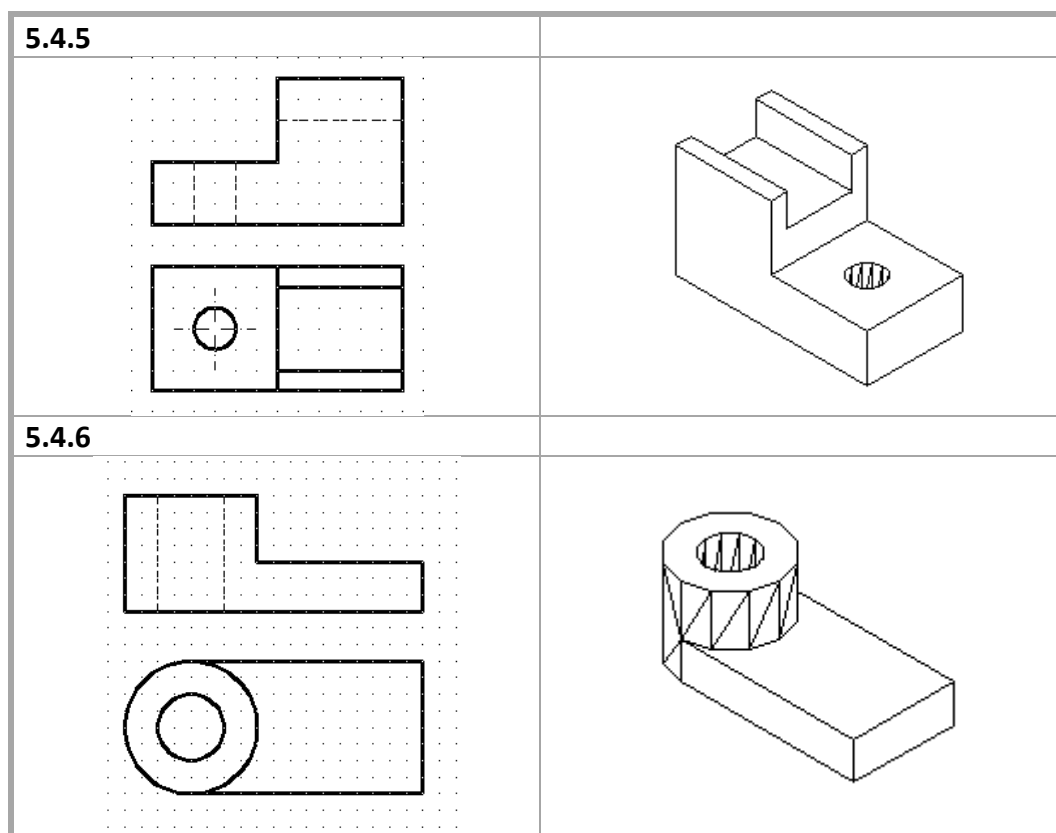
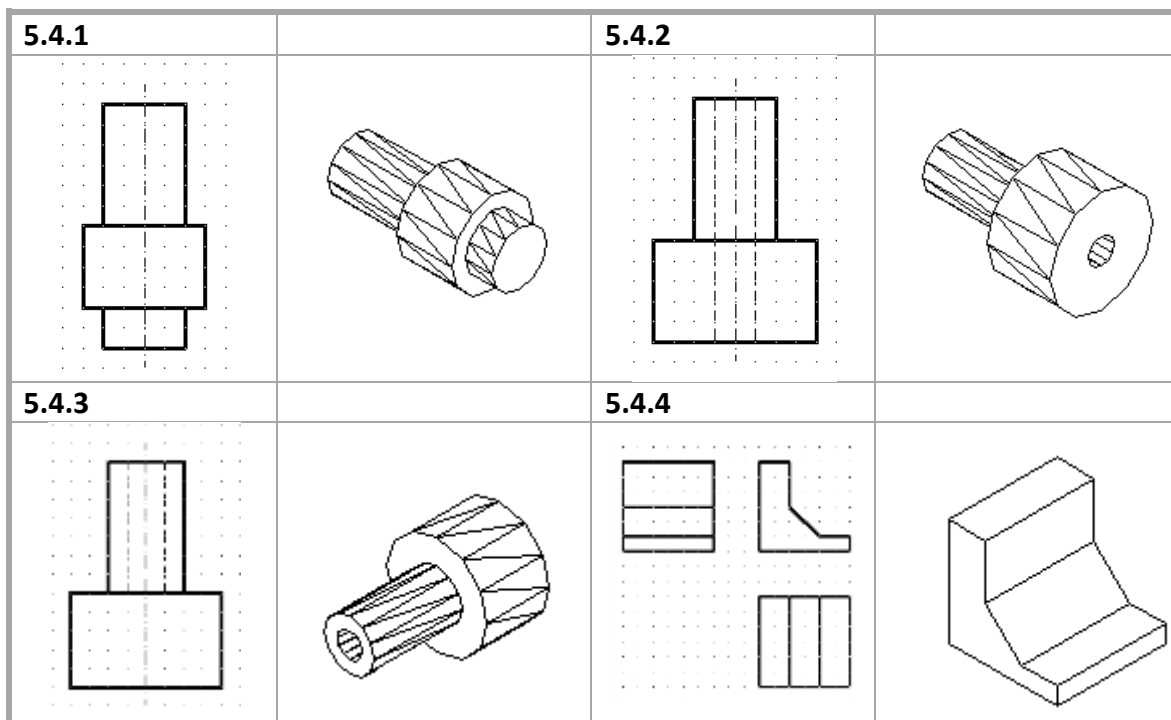
**5.3.3** Desenhe este objeto utilizando os seguintes comandos: . Considere que o diâmetro dos hexágonos é 10 mm, a altura da base 20 mm, a altura dos hexágonos 35 mm e a altura do cilindro central 40 mm.



**5.3.4** Desenhe a peça seguinte a 3D, utilizando os comandos indicados: . A peça tem 50 mm de altura.


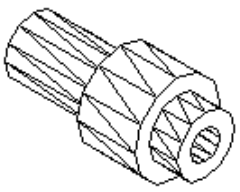
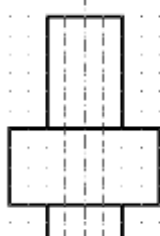
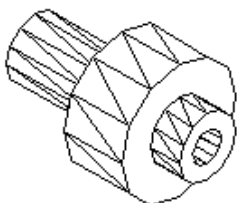

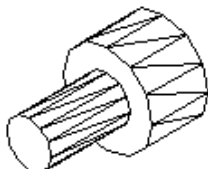
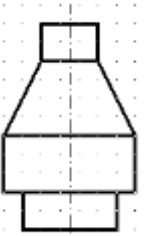
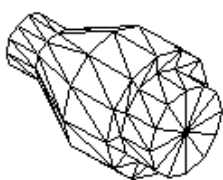
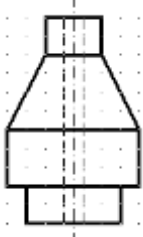
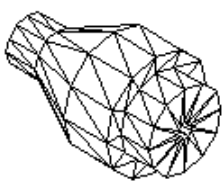
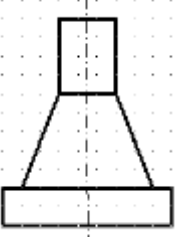
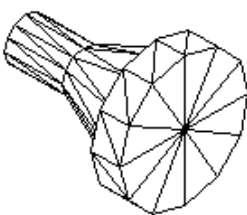
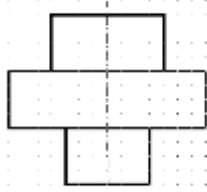
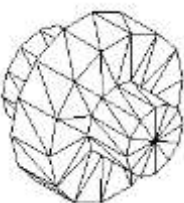
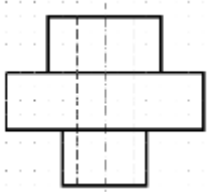

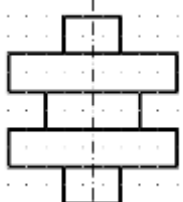
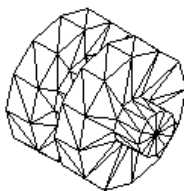
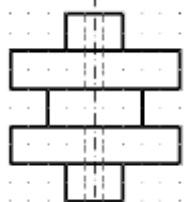
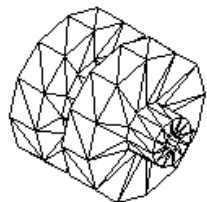


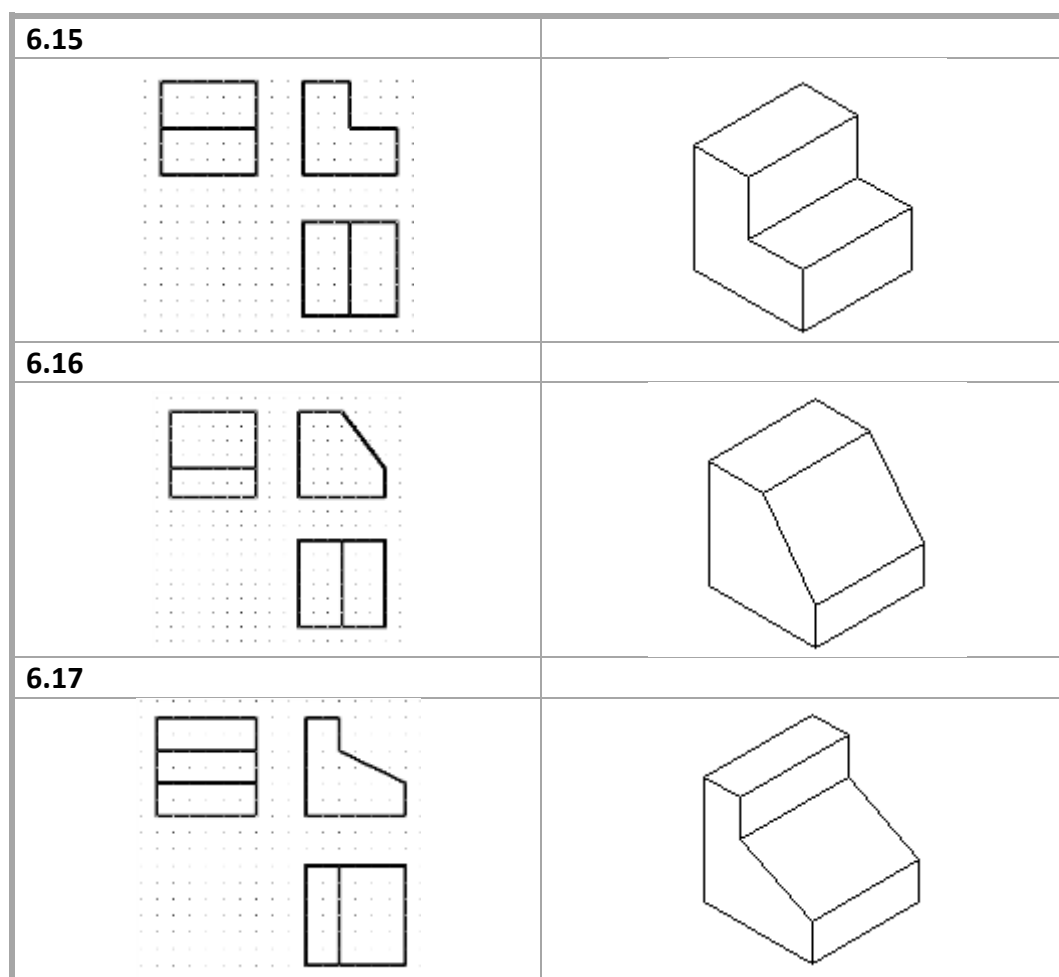
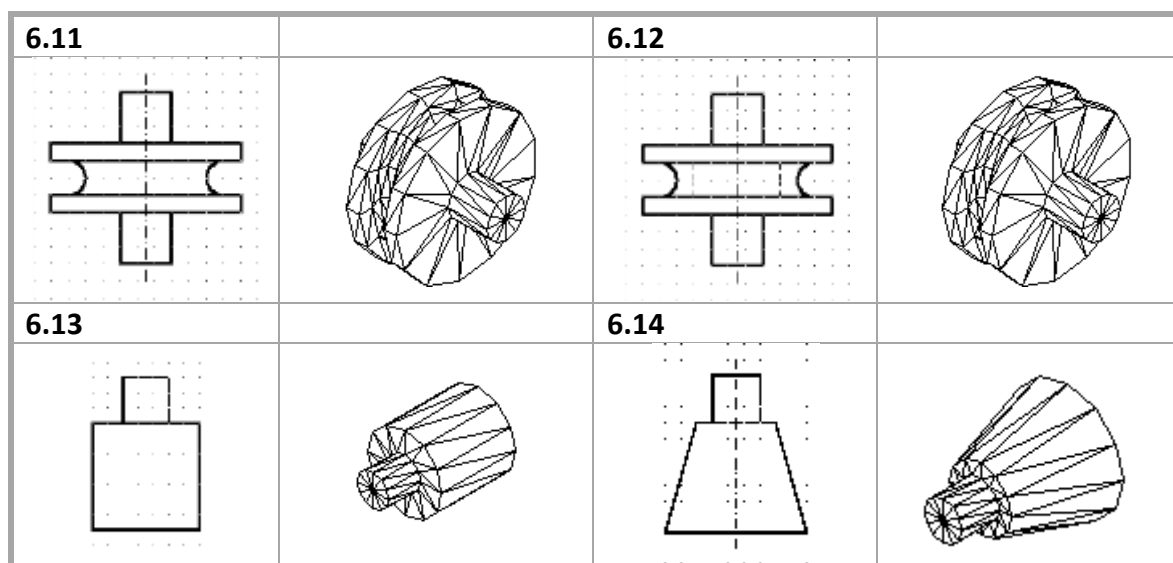
**5.4** Desenhe as peças a 3D (o espaçamento da grelha é 10 unidades). Faça os cortes e as secções, que achar mais conveniente, seleccionando o plano mais adequado.



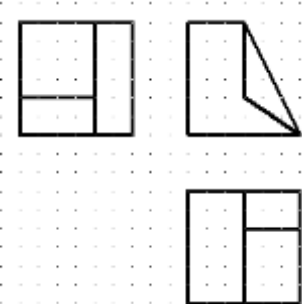
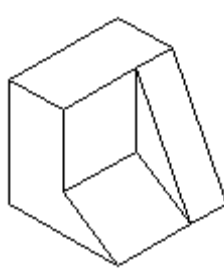
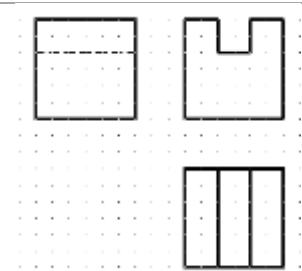
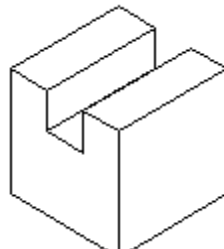
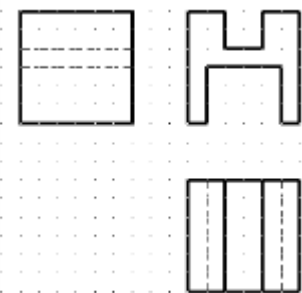
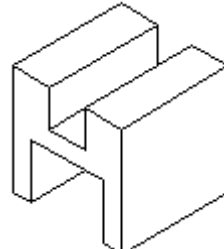
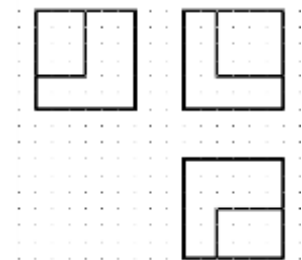
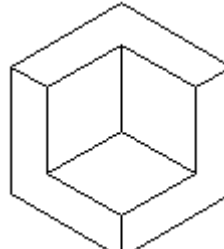
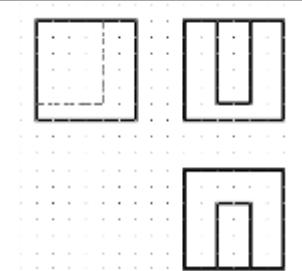
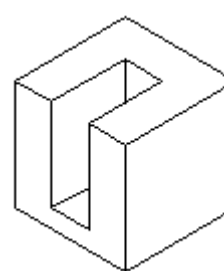
## 6. Exercícios de construção a 3D, cortes e secções

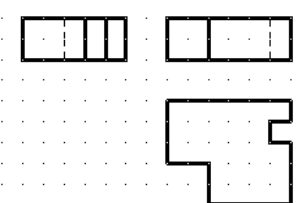
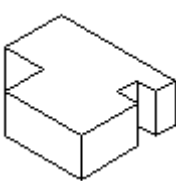
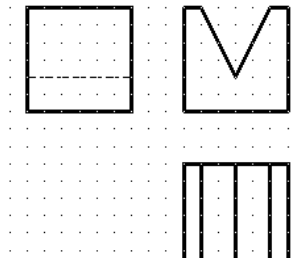
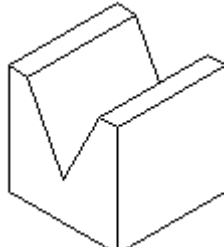
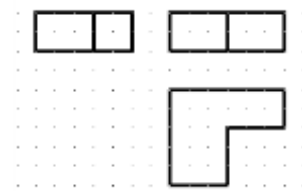
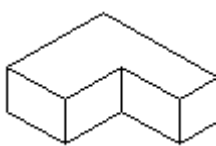
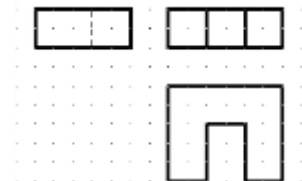
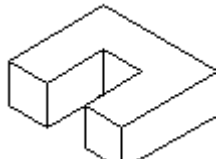

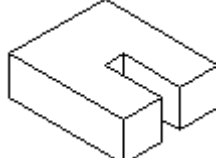
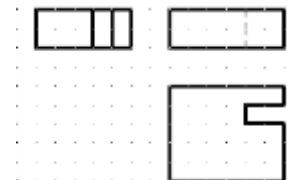
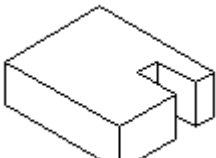
Desenhe as peças a 3D (o espaçamento da grelha é 10 unidades). Faça os cortes e as secções, que achar mais conveniente, seleccionando o plano mais adequado.

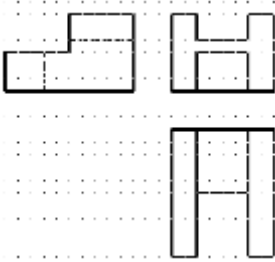
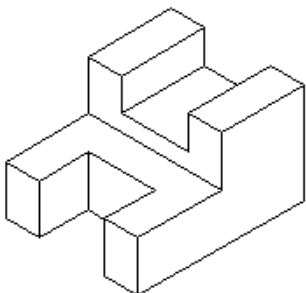
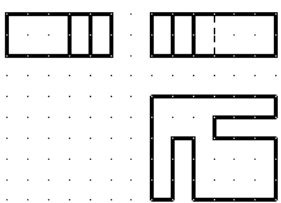
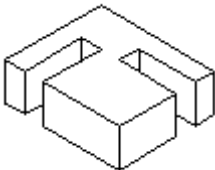
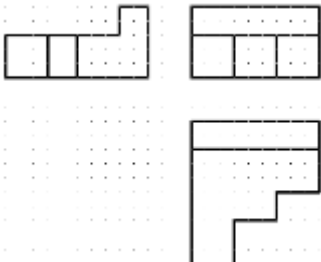
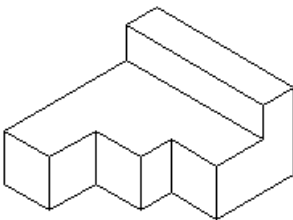
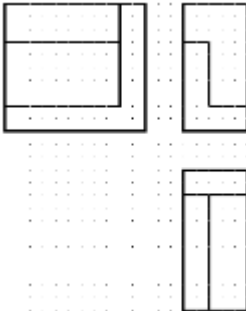
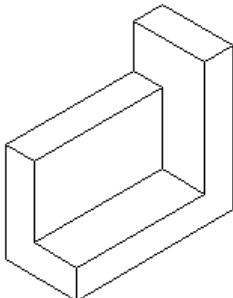
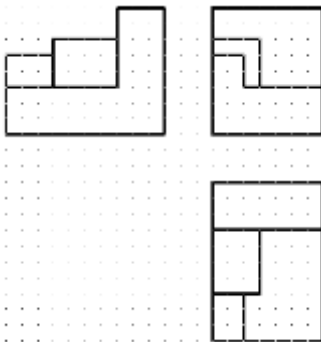
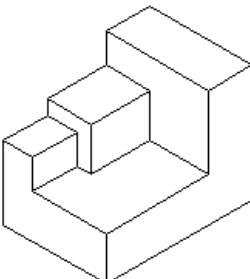
<b>6.1</b> 		<b>6.2</b> 	
<b>6.3</b> 		<b>6.4</b> 	
<b>6.5</b> 		<b>6.6</b> 	
<b>6.7</b> 		<b>6.8</b> 	
<b>6.9</b> 		<b>6.10</b> 	

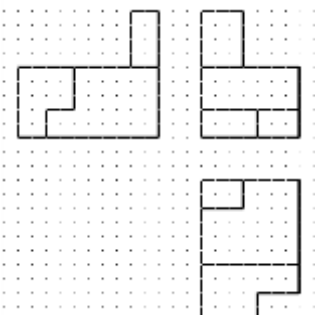
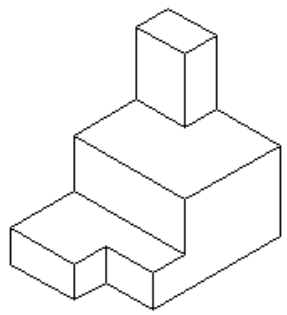
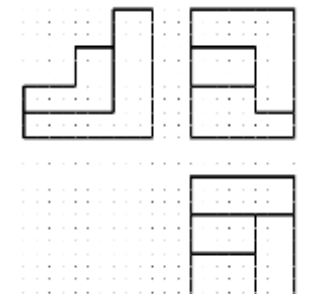
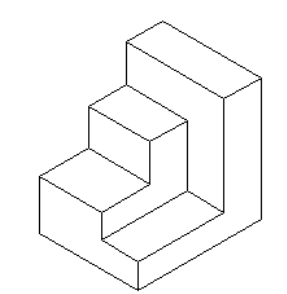
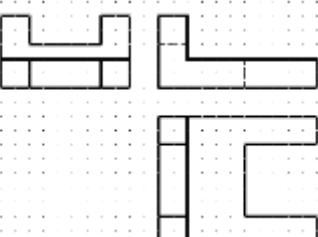
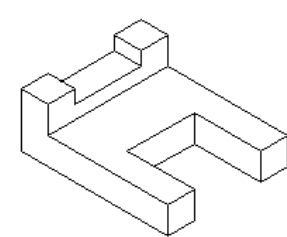
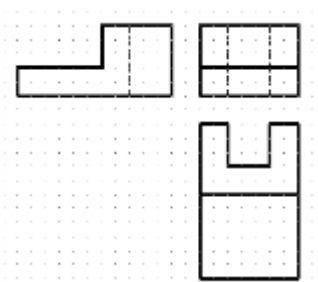
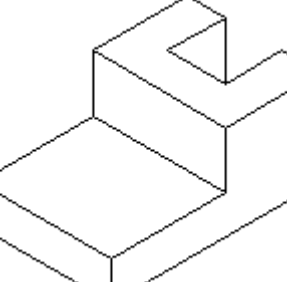
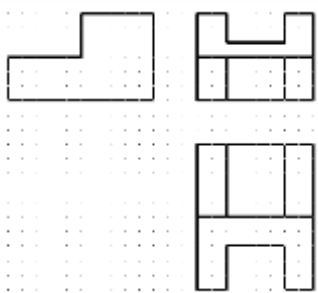
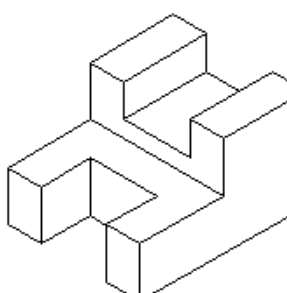


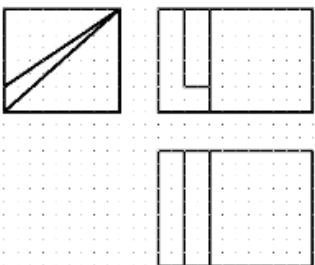
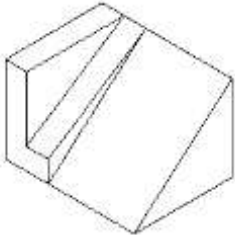
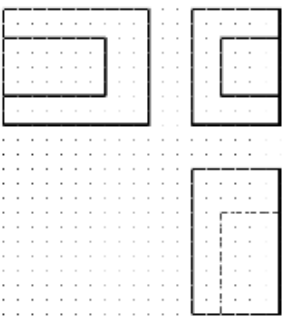
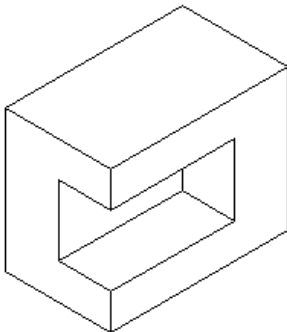
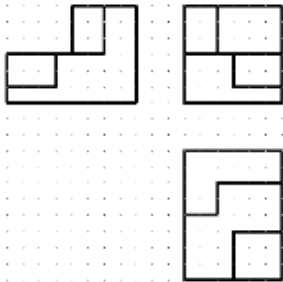
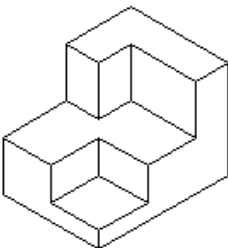
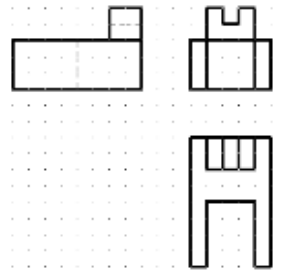
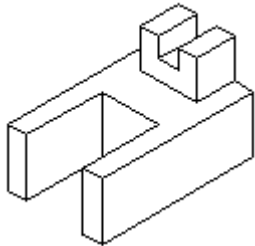
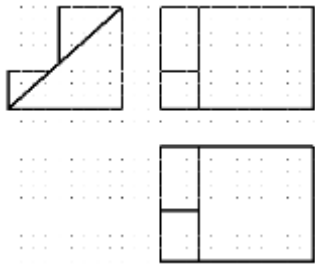
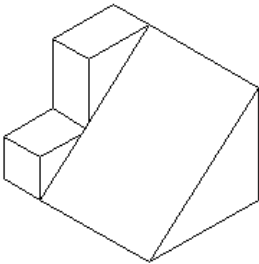


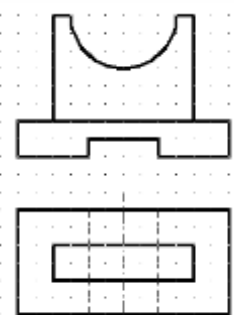
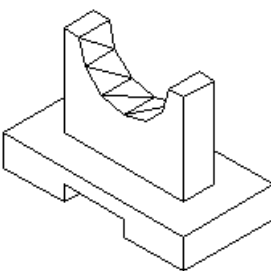
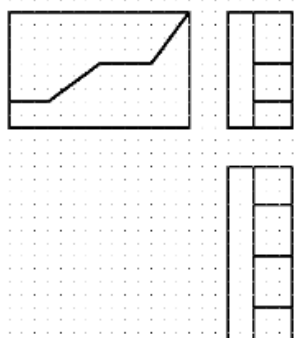
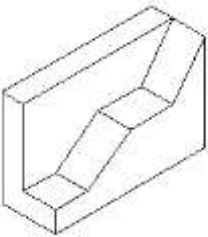
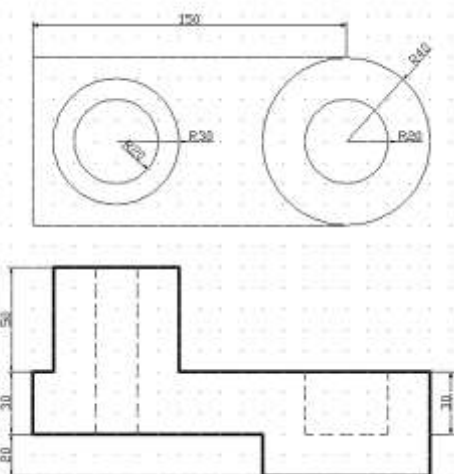
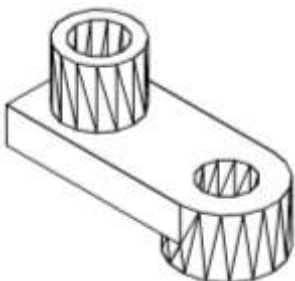
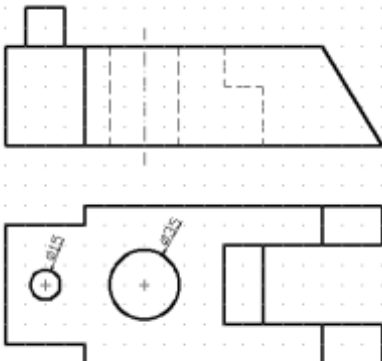
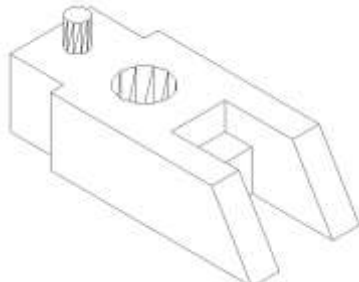
<b>6.18</b> 	
<b>6.19</b> 	
<b>6.20</b> 	
<b>6.21</b> 	
<b>6.22</b> 	

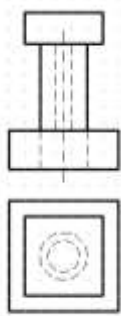
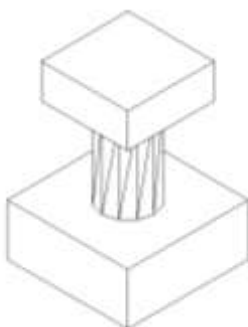
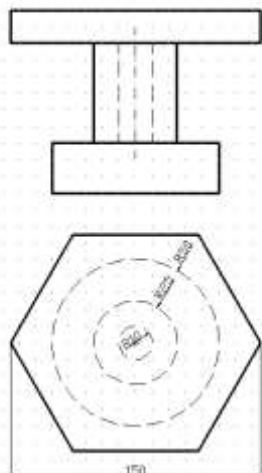
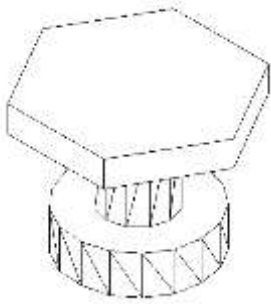
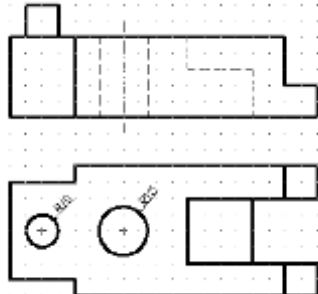
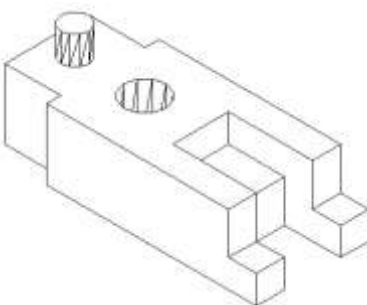
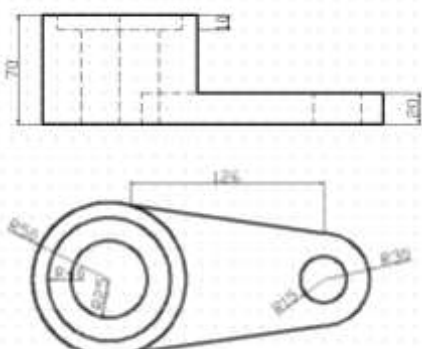
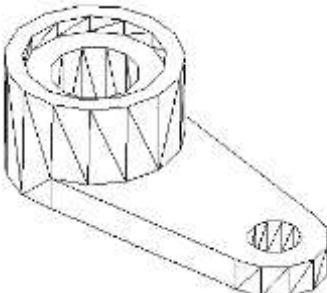
<b>6.23</b> 	
<b>6.24</b> 	
<b>6.25</b> 	
<b>6.26</b> 	
<b>6.27</b> 	
<b>6.28</b> 	

<b>6.29</b> 	
<b>6.30</b> 	
<b>6.31</b> 	
<b>6.32</b> 	
<b>6.33</b> 	

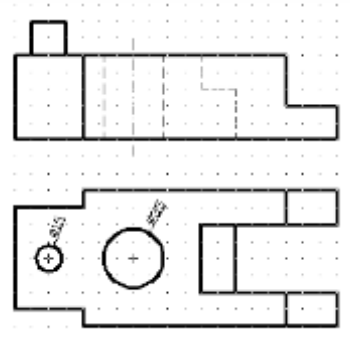
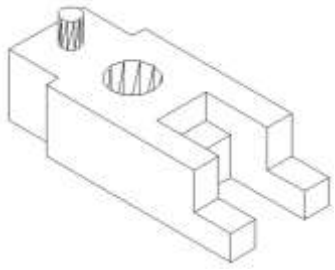
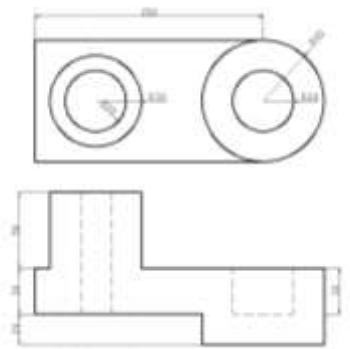
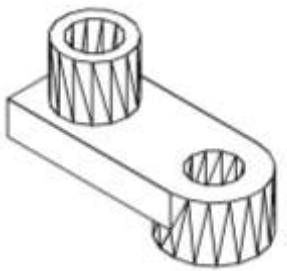
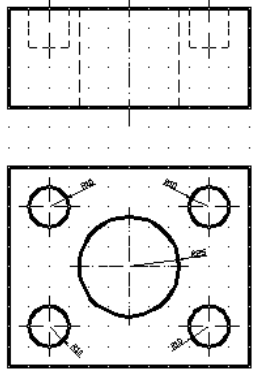
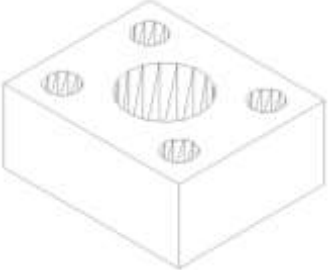
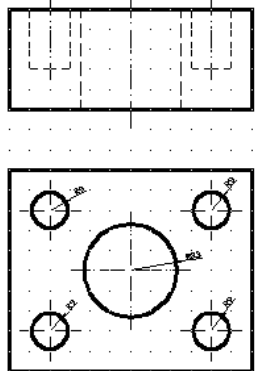
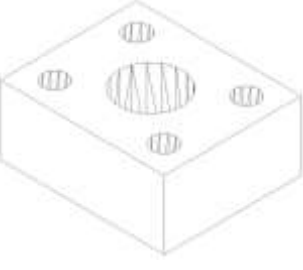
<b>6.34</b> 	
<b>6.35</b> 	
<b>6.36</b> 	
<b>6.37</b> 	
<b>6.38</b> 	

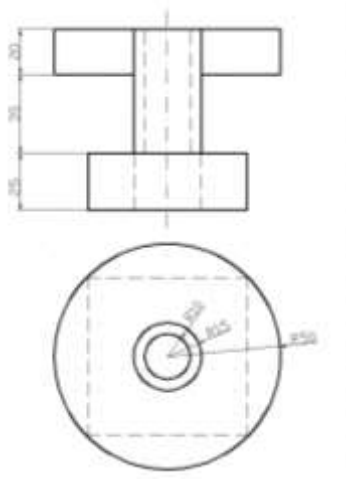
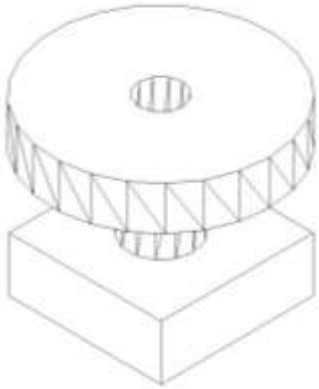
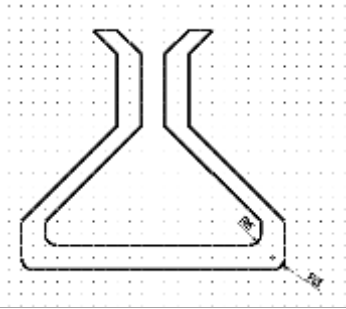
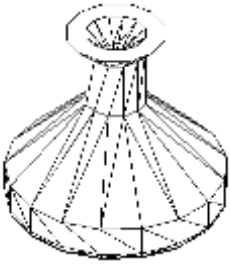
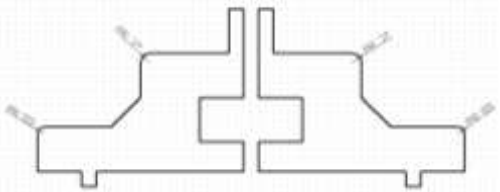

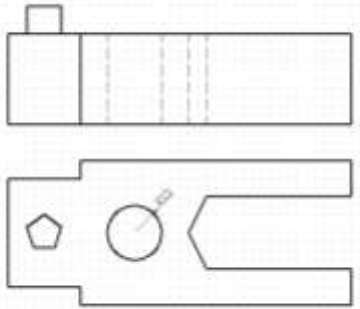
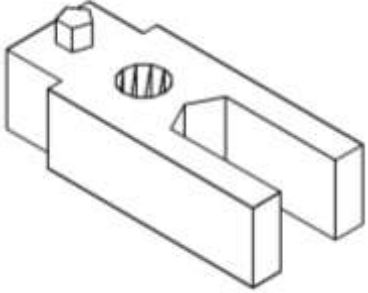
<b>6.39</b> 	
<b>6.40</b> 	
<b>6.41</b> 	
<b>6.42</b> 	
<b>6.43</b> 	




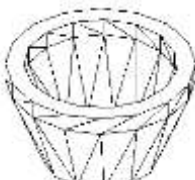
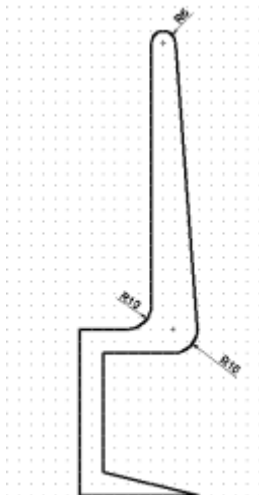

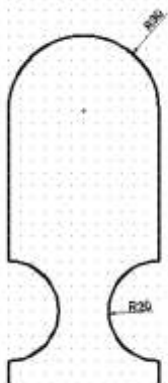
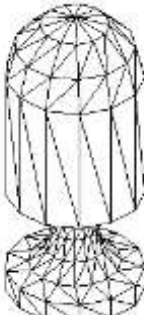
<p><b>6.44</b></p> 	
<p><b>6.45</b></p> 	
<p><b>6.46</b></p> 	
<p><b>6.47</b></p> 	

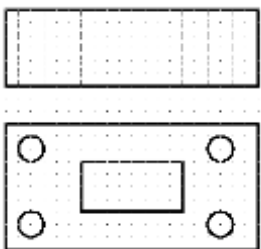
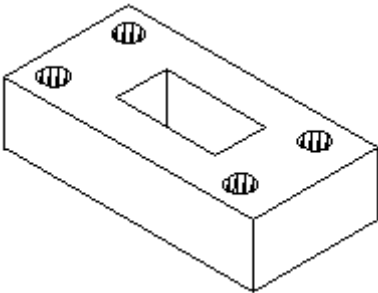
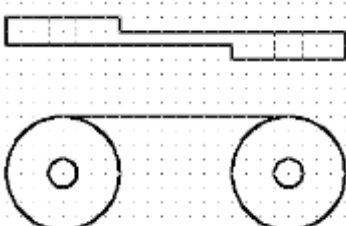
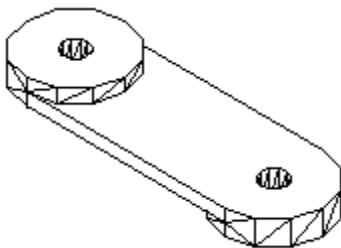
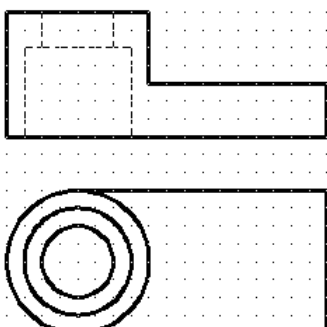
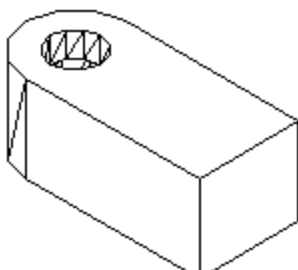
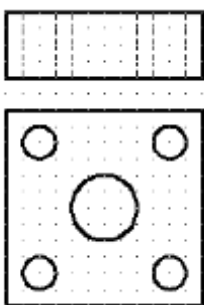
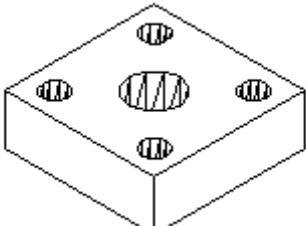
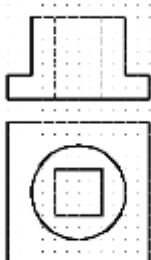
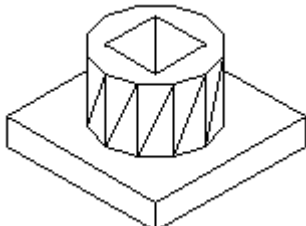
<p><b>6.48</b></p> 	
<p><b>6.49</b></p> 	
<p><b>6.50</b></p> 	
<p><b>6.51</b></p> 	

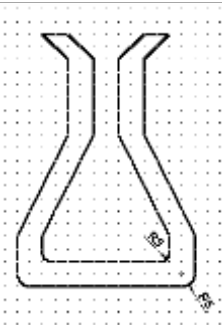
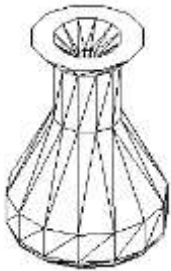
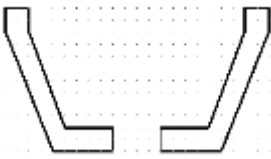
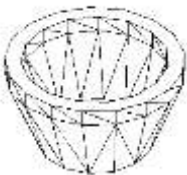
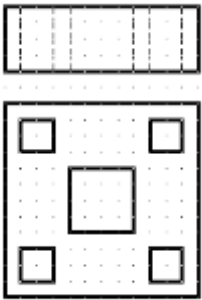
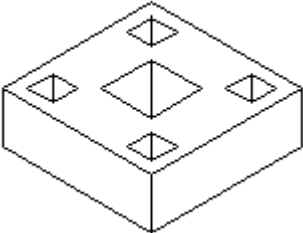
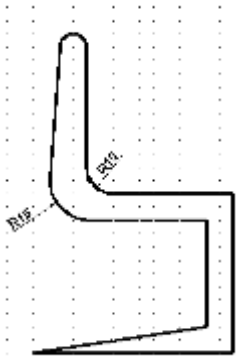
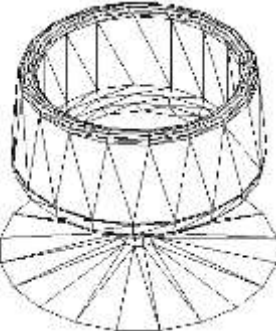
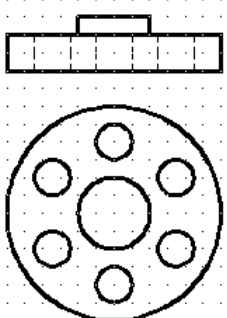
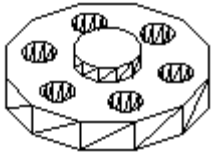


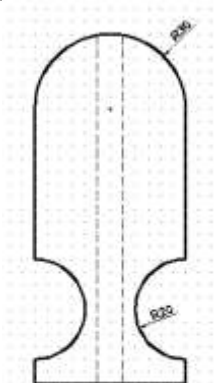
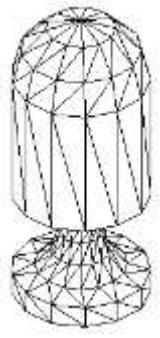
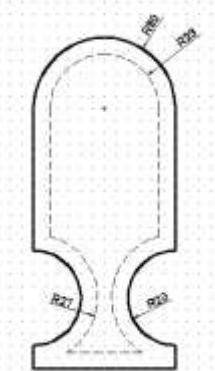

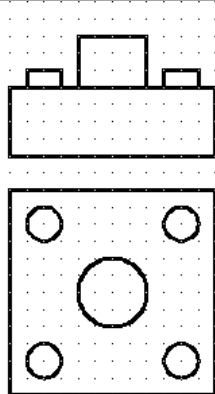
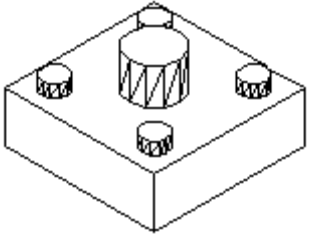
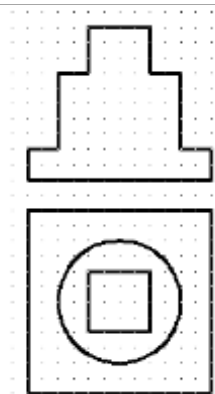
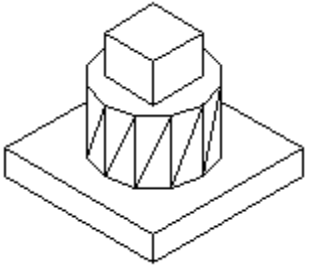
<p><b>6.52</b></p> 	
<p><b>6.53</b></p> 	
<p><b>6.54</b></p> 	
<p><b>6.55</b></p> 	

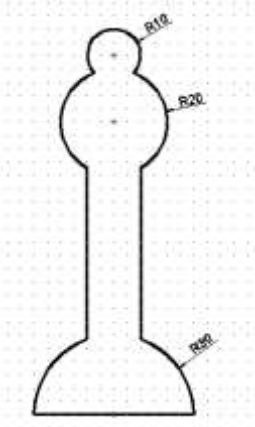

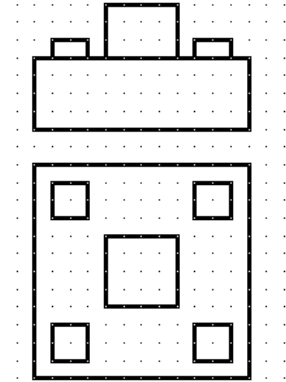
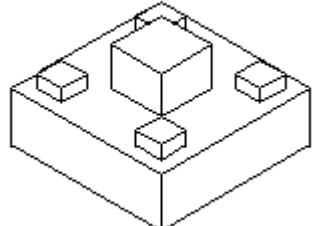
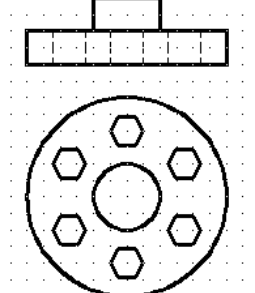
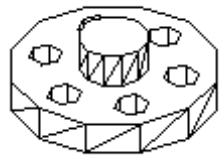
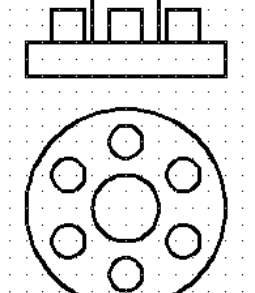
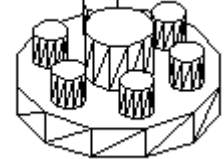
<p><b>6.56</b></p> 	
<p><b>6.57</b></p> 	
<p><b>6.58</b></p> 	
<p><b>6.59</b></p> 	

<p><b>6.60</b></p> 	
<p><b>6.61</b></p> 	
<p><b>6.62</b></p> 	
<p><b>6.63</b></p> 	

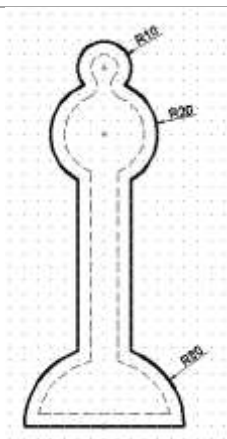
<p><b>6.64</b></p> 	
<p><b>6.65</b></p> 	
<p><b>6.66</b></p> 	
<p><b>6.67</b></p> 	
<p><b>6.68</b></p> 	

<p><b>6.69</b></p> 	
<p><b>6.70</b></p> 	
<p><b>6.71</b></p> 	
<p><b>6.72</b></p> 	
<p><b>6.73</b></p> 	

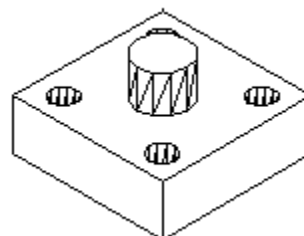
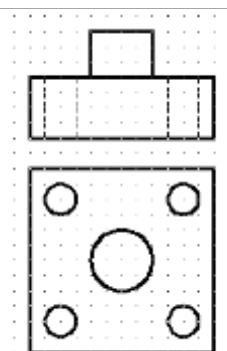
<p><b>6.74</b></p> 	
<p><b>6.75</b></p> 	
<p><b>6.76</b></p> 	
<p><b>6.77</b></p> 	

<p><b>6.78</b></p> 	
<p><b>6.79</b></p> 	
<p><b>6.80</b></p> 	
<p><b>6.81</b></p> 	

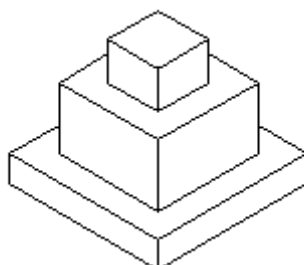
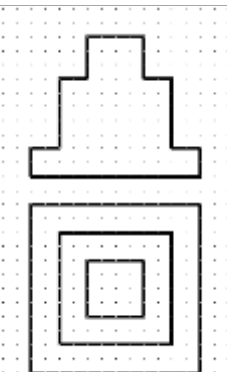
6.82



6.83



6.84



6.85

